05863-15-P

THE UNIVERSITY OF MICHIGAN

COLLEGE OF ENGINEERING
DEPARTMENT OF AEROSPACE ENGINEERING
HIGH ALTITUDE ENGINEERING LABORATORY

Quarterly Progress Report

High Altitude Radiation Measurements

1 July, 1966 - 31 September, 1966

F. L. BARTMAN

Under contract with:

National Aeronautics and Space Administration
Contract No. NASr-54(03)
Washington, D. C.

Administered through: *July 1967*

OFFICE OF RESEARCH ADMINISTRATION • ANN ARBOR

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Table of Contents

List of Tables

List of Illustrations

Abstract

This report summarizes project activity during the period 1 July, 1966 to 30 September, 1966. Progress in the analysis of data obtained on the 8 May 1966 balloon flight, post flight tests and calibrations of the F-4 MRIR and the IRIS instrument, and preparations for the next balloon flight are described.

I Introduction

This is the 15th Quarterly Progress Report on Contract No. NASr-54(03), covering the period 1 July, 1966 to 31 September, 1966. The project effort during this time period was divided among the following tasks:

1. Analysis of Balloon Flight Data.
2. Laboratory testing of the F-4 MRIR radiometer.
3. Laboratory testing of the infra-red interferometer spectrometer.
4. Preparations for the next balloon flight.
5. Report writing.

II Analysis of Balloon Flight Data

The evaluation of data from the 8 May 1966 balloon flight has continued. Summaries of results are given below.

A. Balloon Performance

Balloon performance was summarized in the progress report 05863-14-P. Data on the balloon configuration, weight, the trace of the trajectory over the earth, and the NCAR altitude vs. time curve were shown.

Analysis of pressure altitude data taken by U. of Michigan instrumentation indicates a float altitude slightly different than that obtained by the NCAR photobaro graph. The two sets of data are shown in figure 1. The U. of Michigan data indicates an average float altitude of 7 mb., which is about 0. 7 mb. (1700 feet) higher than indicated by the NCAR instrument. The U. of Michigan data also show greater fluctuations in float altitude during the day.

The difference between these two sets of data is somewhat greater than would be expected and has not been resolved so far.

B. Air Temperature Data

Air temperature data obtained during balloon ascent was also shown in progress report 05863-14-P. Additional data is shown in figures 2 to 6. In figure 2 air temperature data taken during the balloon ascent by U. of Michigan thermister beads is compared with air temperature data obtained with the NCAR radiosonde. The U. M. data is significantly different from the radiosonde data except in the 400-600 mb. region. This difference may be due to errors in calibration of the U. of M. beads, however, since the beads were destroyed when the balloon gondola returned to earth the difference cannot be resolved.

Figure 3, 4 and 5 show air temperature data taken by radiosondes at five Weather Bureau Stations surrounding the launch site at 1200, 1800 and 2400 G. M. T. The rather large spread of temperatures shown by this data at low altitudes and in the tropopause regions eliminates any possibility of resolving the difference in the balloon ascent data noted above.

The smooth curve of air temperature vs pressure altitude which has been adopted for transmissivity calculations is shown in figure 6.

C. Relative Humidity Data

Relative humidity data taken by the radiosondes at 5 stations in the vicinity of the launch site are given in tables 1 to 5. The temperature data plotted in figures 3-5 and the dew point temperature are also given for reference.

D. Gondola Azimuth Data

The interpretation of the "MRIR" radiometer solar radiation channel data requires a knowledge of the azimuth of the scan plane of the radiometer. Azimuth data is obtained by a Disc Instruments, Inc. Model 835 Rotoswitch, which is a photoelectric bi-directional incremental shaft encoder. The field of view of the photocell, determined by a mask with two slits, is a vertical plane. The position of the rotating vertical plane is monitored by the Rotoswitch shaft encoder. The aximuth angle between the vertical plane and a reference line on the balloon gondola is determined from the shaft encoder data for the various times at which the vertical plane passes through the sun. The azimuth of the gondola reference line is then calculated from sun azimuth data and the shaft encoder data.

Figure 7 is a plot of sun azimuth and elevation vs. time for the 8 May 1966 balloon flight. Figure 8 shows the reference line on a plan view of the gondola. Figure 9 shows the time variation of the azimuth of the gondola reference line. In this figure azimuth is measured clockwise from north, as viewed from above. Thus 0^{o} azimuth is north, 90^{o} is east, etc..

The gondola rotational motion indicated in figure 9, is qualitatively typical of the rotations usually obtained on our balloon flights. During the ascent to altitude there are fairly rapid rotations, due to the torque induced at launch and to the torques induced by the changing balloon configuration as it inflates during ascent. The rotation decreases when the balloon arrives at float altitude (0840 EST on this balloon flight). Usually there are occasional small motions during the rest of the flight at float altitude, with a minimum of rotation at local noon, and with noticeable increase in rotation in the afternoon as the sun elevation angle decreases.

The rotational motions at float altitude on this balloon flight were smaller than on other U. of M. balloon flights. This decreased rotation is attributed to the ladder type suspension used on this flight. (see fig. 14 in quarterly report 05863-14-P). On previous flights the long portion of the load line was usually a single long cable, which had less resistance to rotational motions.

On this balloon flight rotational motions of the gondola were introduced deliberately at one hour intervals during the morning. Torques were applied by 10 second jets of dry nitrogen through 2 orifices located on opposite sides of the balloon gondola. The nitrogen supply was carried in a small tank at 2200 psi initial pressure and was released by electrical valves after passing through a pressure regulator which reduced the pressure to about 65 psi. The quantity of gas (14 cu ft. at $70^{\circ}F$ and 1 atmosphere) was sufficient for 11 cycles. On this flight 6 of these occured before launch. The results of 2 of these jets applied at 0720 and 0820 EST are not easily detected in the rotational motions because of the large rotations already existing during ascent. The rotations produced at 0920, 1020 and 1120 EST can be seen in figure 9.

E. Housekeeping Data

Housekeeping data obtained on the 8 May 1966 balloon flight are shown in figures 10-20. Complete data was obtained up to 0750 EST, when the failure of a stepping relay in the calibrate monitor circuit occurred. Figures 10-18 and 20 show data obtained up to this time. Figure 19 shows data obtained from three thermistors for the remainder of the flight.

Figure 10 shows temperatures measured at 3 places in the gondola battery compartment. The decrease in temperature which takes place after launch indicates that the battery compartment insulation was not as effective as it has been on previous flights. Data was not obtained for a long enough time to determine the minimum temperature obtained before the normal increase which occurs at float altitude during the day. However extrapolation of the decrease of the temperature of the bottom of the battery compartment to 0920 EST., in direct analogy to the decrease of the distribution box air temperature shown in figure 19, indicates a temperature minimum of perhaps 8°C. Although this temperature is not dangerous for battery operation, it is much lower than should be obtained with proper insulation.

Figures 11, 12 and 13 show temperatures at various locations inside and on top of the gondola. These locations are protected from the cold air in the tropopause by at least one inch of polyethelene beadboard. The cameras (fig. 11) are all protected against low temperatures by heaters with thermostats that operate at 6° C and therefore do not go below this temperature. The decrease obtained after launch for the other locations is quite normal.

Temperatures of the IRIS (Infrared Interferometer Spectrometer) instrumentation are shown in figure 14. The head and warm blackbody temperatures are controlled. The temperature of the electronics package shows a variation which is considered to be normal for an instrument inside of the second level of the gondola.

Filter wedge instrumentation temperatures are shown in figure 15. Again, the decrease in temperature of the door and electronic package are quite normal. Since a fairly large amount of power was dissipated in the instrument itself, the filter wedge bolometer, blackbody and the edge of the bottom plate do not show much temperature decrease after launch.

MRIR temperature data is shown in figures 16-19. Figure 16 shows temperatures of the auxiliary mirror, which has no insulation, and the door motor which is only poorly insulated. The mirror temperature minimum of -32.5°C. was the lowest temperature recorded on the balloon gondola. The

The MRIR door motor (fig. 16), the MRIR door and the MRIR (fig. 17) distribution box show successively higher temperature minima, consistant with their power dissipation and insulation. MRIR instrument temperatures are shown in figure 18 and are as expected.

Figure 19 shows the three "housekeeping" temperatures measured throughout the flight. The MRIR mirror temperatures shows the extreme temperature variations which are to be expected of an uninsulated portion of the gondola. The temperature maxima are due to direct illumination by the sun. The MRIR chopper #1 temperature indicates a minimum temperature of $9^{\circ}C$. and shows fluctuations due to solar heating. The distribution chassis air temperature shows an increase consistant with continuous illumination of the gondola by the sun.

Figure 20 shows voltages of the thermister power supply which remained constant as long as they were measured.

F. IRIS (Infrared Interferometer Spectrometer) Data Analysis

The technique of analysing the IRIS data was perfected during this quarterly work period. Details of the work included:

1. Analog interferograms were put into IBM compatible format with the use of the Meteorological Department CDC computer.

2. Individual interferograms were carefully examined and a few selected for the calculation of spectra.

3. The analytical technique of applying calibrations was developed and programs were written for this purpose.

4. After considerable effort, it was realized that the pre-flight calibrations were not valid and so in-flight calibrations were used for data analysis.

At the end of this work period, spectra had been calculated for all of the interferograms selected.

III Laboratory Testing of the F-4 MRIR Radiometer

The thermal channels of the F-4 MRIR have been recalibrated. These post-flight calibrations are in basic agreement with pre-flight calibrations made in February, 1966 and thus demonstrate that no serious damage was done to the instrument in the launch disaster of 26 May 1966. A portion of the data with both scanner and electronics module at 25°C. is shown in tables 6-9.

IV Laboratory Testing of the (IRIS) Interferometer

Laboratory Tests of the IRIS instrument included a check of resolution and a post flight calibration. The Laboratory's large blackbody source was re-built and a new dry box was constructed for the calibrations.

The resolution check and calibrations demonstrated two facts:

a) That the interferometer suffered no deterioration in performance during the flight.

b) The pre-flight calibrations carried out at Bendix Systems Division and at Chrysler Missile Division were not valid because of contamination of the calibration chamber by water vapor.

As a result, data analysis of the 8 May 1966 balloon flight data has been carried out using in-flight calibration data and a new environmental chamber has been purchased for use in carrying out interferometer calibrations in the future.

V Preparations for the Next Balloon Flight

Work in preparation for the next balloon flight can be divided into two categories; repair of old equipment and design and construction of new equipment.

Equipment repaired included:

a) The pressure altitude measuring unit.

b) Cameras (repaired by J. A. Maurer Co.).

c) Brush recorders.

d) Thermisters for measurement of "housekeeping" temperature data.

e) The MRIR electronics (distribution) chassis.

After the construction and testing of prototype circuits for a new gondola timing and control system, parts were ordered for the new system.

VI Report Writing

A paper, published in May, 1966, and not reported on in the quarterly report covering that period is "The Effect of Time Jitter in the Sampling of an Interferogram", by M. T. Surh, Applied Optics vol. 5, pp 880, May 1966.

Another paper, by S. R. Drayson and C. Young, "Intensities of the Carbon Dioxide Band in the 12-18 Micron Spectral Region," was presented at the Symposium on Molecular Structure and Spectroscopy, Ohio State University Sept., 1966. The work reported on was performed in part on this project and partly under another contract, cwb-11376.

VII <u>Future Work</u>

The main effort during the next work period will be devoted to:

1) Data analysis

2) Construction of new balloon flight instrumentation

3) Report Writing

TABLE I METEOROLOGICAL DATA, Lake Charles, La.

8 May 1966 1200 GMT				8 May 1966 1800 GMT				9 May 1966 0000 GMT			
P(mb)	T(°C)	RH%	T_D(°C)	P(mb)	T^o(C)	RH%	T_D(°C)	P(mb)	T(°C)	RH%	T_D(°C)
1008	17.8	90	16.1	1009	27.2	57	17.8	1006	27.2	39	12.1
994	22.1	68	15.9	996	24.8	48	13.1	807	11.0	62	4.0
923	17.8	61	10.2	826	11.0	63	4.2	772	8.2	71	3.2
794	7.5	99	7.4	782	6.7	86	4.5	709	5.6	35	-8.7
696	2.5	76	-1.4	740	3.7	67	-1.9	582	-2.5	48	-12.0
661	1.9	51	-7.2	720	3.7	47	-6.5	508	-11.2	53	-18.9
568	-5.8	58		708	5.5	39	-7.4	481	-14.4	63	-19.9
536	-9.3	72	-13.5	654	2.8	45	-8.0	446	-19.2	61	-24.8
516	-10.6	54	-18.1	538	-7.4	43		438	-19.6	44	-28.8
412	-23.9	33	-26.0	460	-16.5	43	-26.2	400	-24.3	18	-41.9
400	-24.9	72		438	-19.5	52	-26.9	292	-39.9	18	-55.2
388	-26.7	58	-32.5	400	-24.0	38	-34.4	221	-51.5		
300	-40.0	35	-49.6	328	-36.2	20	-51.2	176	-59.7		
249	-50.2			297	-40.0	18	-55.3	162	-58.4		
173	-61.2			244	-49.0			156	-60.1		
164	-59.0			199	-56.0			142	-58.7		
152	-61.6			193	-55.4			110	-63.3		
107	-63.8			162	-62.0			100	-62.8		
100	-61.6			132	-60.5			72	-64.3		
69	-64.0			107	-62.2			59	-60.8		
55	-59.6			100	-61.1			52	-61.1		
50	-61.6			91	-59.6			50	-57.5		
26	-48.0			75	-65.2			38	-54.0		
14	-43.8			40	-52.8			35	-55.9		
10	-37.2			26	-50.0			27	-48.7		
				20	-41.7			25	-49.6		
				15	-39.9			16	-43.2		

TABLE 2 METEOROLOGICAL DATA, Shreveport, La.

8 May 1966 1200 GMT				8 May 1966 1800 GMT				9 May 1966 000 GMT			
P(mb)	T(°C)	RH%	T_D(°C)	P(mb)	T(°C)	RH%	T_D(°C)	P(mb)	T(°C)	RH%	T_D(°C)
1000	14.9	95	14.1	1000	25.7	51	14.8	997	28.4	43	14.6
986	22.3	60	14.1	851	12.2	66	6.0	986	26	44	12.8
850	12.8	64	6.2	832	14.2	31	-2.7	852	14.6	58	6.4
824	12.8	41	-0.1	602	-2.6	29		808	12.9	30	-4.3
720	6.0	44	-5.4	486	-14.7	43	-24.5	613	-2.3	30	
584	-7.5	44	-17.7	400	-24.7	27	-38.4	458	-17.6	29	-31.4
552	-8.2	44	-18.3	342	-33.9	26		311	-39.8	30	-50.8
	-17.0	33		303	-40.0	28	-51.6	260	-48.8		
400	-26.0	33	-37.6	251	-48.3			204	-57.1		
310	-40.0	35	-49.7	197	-56.5			160	-61.1		
259	-48.4			132	-62.8			130	-60.2		
207	-56.6			100	-61.0			115	-63.0		
171	-60.8			92	-60.3			96	-61.7		
162	-59.2			82	-63.5			79	-64.5		
136	-63.0			54	-56.7			29	-49.6		
108	-61.3			43	-56.7			18.5	-45.4		
100	-63.3			10	-34.6			10	-36.8		
62	-62.0			8	-35.5						
37	-51.3										
32	-52.5										
22	-44.8										
10	-37.7										
7	-37.3										

TABLE 3 METEOROLOGICAL DATA, Fort Worth, Texas

8 May 1966 0600 GMT			
P(mb)	T(^oC)	RH%	T_D(^oC)
991	19.8	78	15.9
968	22.9	57	13.9
868	16.0	58	7.7
840	14.2	41	1.1
684	3.2	28	-13.5
654	0.5	44	-10.4
616	-2.5	28	-18.5
605	-1.5	16	-24.1
574	-4.2	17	
400	-26.1	20	-42.5
333	-37.0	20	-51.8
309	-40.0	20	-54.5
268	-46.8		
228	-51.8		
223	-51.8		
200	-58.0		

8 May 1966 1200 GMT			
P(mb)	T(^oC)	RH%	T_D(^oC)
989	16.0	90	14.4
962	21.0	51	10.5
840	13.3	41	0.3
789	9.0	71	4.0
735	7.7	21	-13.3
704	5.0	26	
654	-0.2	51	-9.1
642	0.2	23	-18.5
590	-3.3	16	-25.6
400	-26.8	18	-44.0
350	-34.1	18	-50.2
310	-40.0	18	-55.3
269	-47.5		
195	-60.3		
185	-59.6		
148	-64.0		
141	-62.0		
122	-64.0		
115	-62.2		
108	-64.0		
100	-62.3		
82	-66.0		
40	-57.1		
34	-51.7		
30	-52.9		
18	-43.8		
15	-41.7		

8 May 1966 1800 GMT			
P(mb)	T(^oC)	RH%	T_D(^oC)
989	26.2	51	15.2
979	23.6	39	8.8
844	13.5	32	-2.9
807	11.8	46	0.5
775	11.1	21	-10.5
666	2.9	24	-15.7
655	4.0	15	-20.3
520	-7.7	15	
400	-24.8	16	-43.5
304	-40.0	15	-56.8
227	-54.1		
200	-57.8		

9 May 1966 0000 GMT			
P(mb)	T(^oC)	RH%	T_D(^oC)
986	27.0	48	15.0
868	16.3	54	7.0
847	16.7	19	-7.1
802	15.3	17	-9.6
732	9.5	15	-15.8
722	10.8	15	-14.8
591	-1.9	18	
476	-13.8	18	
400	-24.3	18	-42.0
299	-40.0	20	-54.4
226	-54.7		
212	-56.1		
196	-59.9		
172	-63.4		
163	-62.6		
158	-59.6		
138	-62.1		
127	-60.3		
118	-62.9		
114	-62.1		
100	-64.8		
92	-63.1		
82	-64.5		
75	-62.0		
65	-64.0		
43	-55.5		
35	-50.0		
31	-51.6		
28	-47.5		
26	-48.1		
18	-43.3		

TABLE 4 METEOROLOGICAL DATA, Midland, Texas

8 May, 1966 1200 GMT				8 May, 1966 1800 GMT				9 May 1966 0000 GMT			
P(mb)	T(^{o}C)	RH%	T_D(^{o}C)	P(mb)	T(^{o}C)	RH%	T_D(^{o}C)	P(mb)	T(^{o}C)	RH%	T_D(^{o}C)
910	14.0	71	8.8	910	26.9	30	7.8	916	31.5	19	5.0
886	19.1	44	6.6	900	24.6	27	4.4	892	29.0	18	2.3
833	18.6	18	-6.1	836	19.1	24	-1.9	700	11.1	25	
787	17.0	20	-6.1	796	18.5	22	-3.6	622	2.9	27	
633	2.8	23	-16.3	733	12.9	22		568	-3.5	27	-19.8
533	-9.4	32	-23.0	642	3.3	26	-14.4	548	-4.5	17	-25.9
523	-9.2	18	-29.3	620	0.3	39	-12.1	400	-23.1	18	-40.9
480	-13.5	17	-33.4	561	-6.4	33	-20.0	290	-40.0		
400	-24.5	21	-40.7	550	-6.4	19	-26.3	216	-57.2		
362	-29.6	19		531	-7.1	17	-28.1	165	-64.0		
304	-40.0	25	-52.5	463	-16.0	18		156	-59.1		
284	-44.0			400	-24.3	19	-41.5	142	-61.8		
264	-46.2			340	-34.0	21	-48.9	130	-60.8		
186	-61.1			297	-40.0	20	-54.4	100	-65.0		
173	-63.4			201	-60.0			76	-65.8		
157	-60.9			176	-61.6			58	-64.1		
146	-63.4			171	-61.1			50	-59.0		
114	-61.5			153	-63.0			38	-57.6		
100	-64.3			145	-60.5			25	-46.8		
57	-63.4			121	-60.0			10	-38.0		
48	-58.8			106	-63.4			7	-30.0		
40	-58.5			100	-62.5			5.6	-31.2		
38	-54.5			59	-62.5						
10	-35.9			54	-58.0						
8	-36.2			44	-58.5						
				34	-51.4						
				21	-44.3						
				17	-42.9						
				13.5	-36.3						
				10	-33.2						

TABLE 5 METEOROLOGICAL DATA, San Antonio, Texas

8 May 1966 1200 GMT				8 May 1966 1800 GMT				9 May 1966 0000 GMT			
P(mb)	T(^{o}C)	RH%	T_D(^{o}C)	P(mb)	T(^{o}C)	RH%	T_D(^{o}C)	P(mb)	T(^{o}C)	RH%	T_D(^{o}C)
982	13.3	97	12.8	982	25.0	60	16.7	979	27.2	47	14.9
966	16.6	100	16.6	966	22.5	53	12.4	872	16.8	58	8.5
922	14.8	90	13.3	905	16.5	71	11.2	823	12.6	65	6.2
895	15.6	63	8.6	827	12.3	45	0.7	764	8.0	58	0.2
839	11.1	85	8.6	758	5.7	48	-4.5	746	9.5	23	-10.6
814	10.7	62	3.7	728	6.1	23	-13.5	708	8.2	16	-16.2
739	4.0	62	-2.6	698	7.8	19	-14.5	704	9.1	16	-15.5
719	3.4	35	-10.6	590	-2.2	19		638	4.5	15	-19.9
697	5.7	14	-19.8	400	-24.5	20	-41.2	466	-15.4	15	
674	5.2	14	-20.2	326	-35.9	21		400	-23.6	17	-41.9
600	-1.2	15	-24.6	309	-38.9	23	-52.3	343	-32.5	17	
430	-22.5	18	-40.4	200	-56.0			294	-40.0	18	-55.3
400	-25.0	18	-42.5	178	-59.6			204	-57.8		
365	-25.0			160	-57.5			193	-59.0		
298	-40.0			151	-60.6			190	-57.6		
275	-43.9			140	-60.1			172	-60.3		
215	-54.7			132	-61.7			152	-60.1		
192	-59.4			127	-60.9			142	-57.6		
168	-61.7			111	-64.2			129	-61.9		
157	-61.5			100	-62.8			112	-63.6		
151	-62.4			67	-66.1			100	-67.7		
130	-61.2			45	-56.0			95	-69.2		
120	-61.4			40	-55.7			84	-64.9		
106	-65.2			31	-50.6			62	-65.3		
100	-63.8							36	-51.2		
78	-64.8							28	-51.2		
63	-66.0							23	-45.2		
44	-57.5							17	-44.8		
18	-44.7										
14	-43.2										

TABLE 6 F-4 MRIR CALIBRATION DATA

6.7 Micron Channel

Scanner 25°/Electronics 25°

°C	S. B. 10/2/64	S. B. 10/12/64	U. M. 2/65	S. B. 4/8/65	U. M. 9/65	S. B. 12/20/65	S. B. 12/29/65	U. M. 2/1/66	U. M. 7/6/66
-93	5.20	5.25	--	4.70	4.95	4.70	4.70	5.15	--
-83	5.15	5.15	--	4.60	4.85	4.65	4.65	5.00	4.88
-73	5.00	5.10	--	4.40	4.65	4.55	4.55	4.84	4.75
-63	4.80	4.90	4.20	4.25	4.40	4.30	4.30	4.56	4.50
-53	4.50	4.55	3.95	3.95	4.05	4.10	4.10	4.25	4.13
-43	4.05	4.05	3.55	3.45	3.60	3.60	3.60	3.75	3.63
-33	3.40	3.40	2.90	2.80	3.05	3.00	3.00	3.10	2.95
-23	2.55	2.60	2.05	2.10	2.20	2.10	2.10	2.26	2.10
-13	1.50	1.50	1.00	1.05	1.10	1.10	1.10	1.15	1.00
-3	--	--	--	--	--	--	--	--	--

TABLE 7 F-4 MRIR CALIBRATION DATA

10-11 Micron Channel

Scanner 25^{o}/Electronics 25^{o}

^{o}C	S. B. 10/2/64	S. B. 10/12/64	U. M. 2/65	S. B. 4/8/65	U. M. 9/65	S. B. 12/20/65	S. B. 12/29/65	U. M. 2/1/66	U. M. 7/6/66
-93	6.30	6.25	--	6.10	6.10	6.10	6.05	--	--
-83	6.20	6.15	--	6.00	6.05	6.00	5.95	6.14	5.90
-73	6.00	6.05	--	5.90	5.90	5.85	5.80	5.96	5.80
-63	5.85	5.85	5.60	5.65	5.70	5.65	5.65	5.75	5.60
-53	5.65	5.60	5.40	5.45	5.45	5.45	5.40	5.50	5.35
-43	5.35	5.30	5.15	5.15	5.15	5.15	5.10	5.19	5.05
-33	5.00	5.00	4.80	4.85	4.80	4.85	4.85	4.85	4.70
-23	4.60	4.55	4.40	4.40	4.40	4.45	4.35	4.45	4.30
-13	4.05	4.10	3.90	4.00	3.95	3.95	3.90	3.99	3.85
-3	3.55	3.50	3.40	3.50	3.45	3.50	3.40	3.45	3.35
7	3.00	3.20	2.85	2.90	2.90	2.90	2.85	2.85	2.75
17	2.30	2.25	2.20	2.25	2.25	2.25	2.20	2.20	2.15
27	1.50	1.50	1.50	1.50	1.55	1.55	1.50	1.50	1.50
37	0.65	0.70	--	0.70	0.75	0.75	0.70	0.70	0.75
47	--	--	--	--	--	--	--	--	--

TABLE 8 F-4 MRIR CALIBRATION DATA

14-16 Micron Channel

Scanner 25°/Electronics 25°

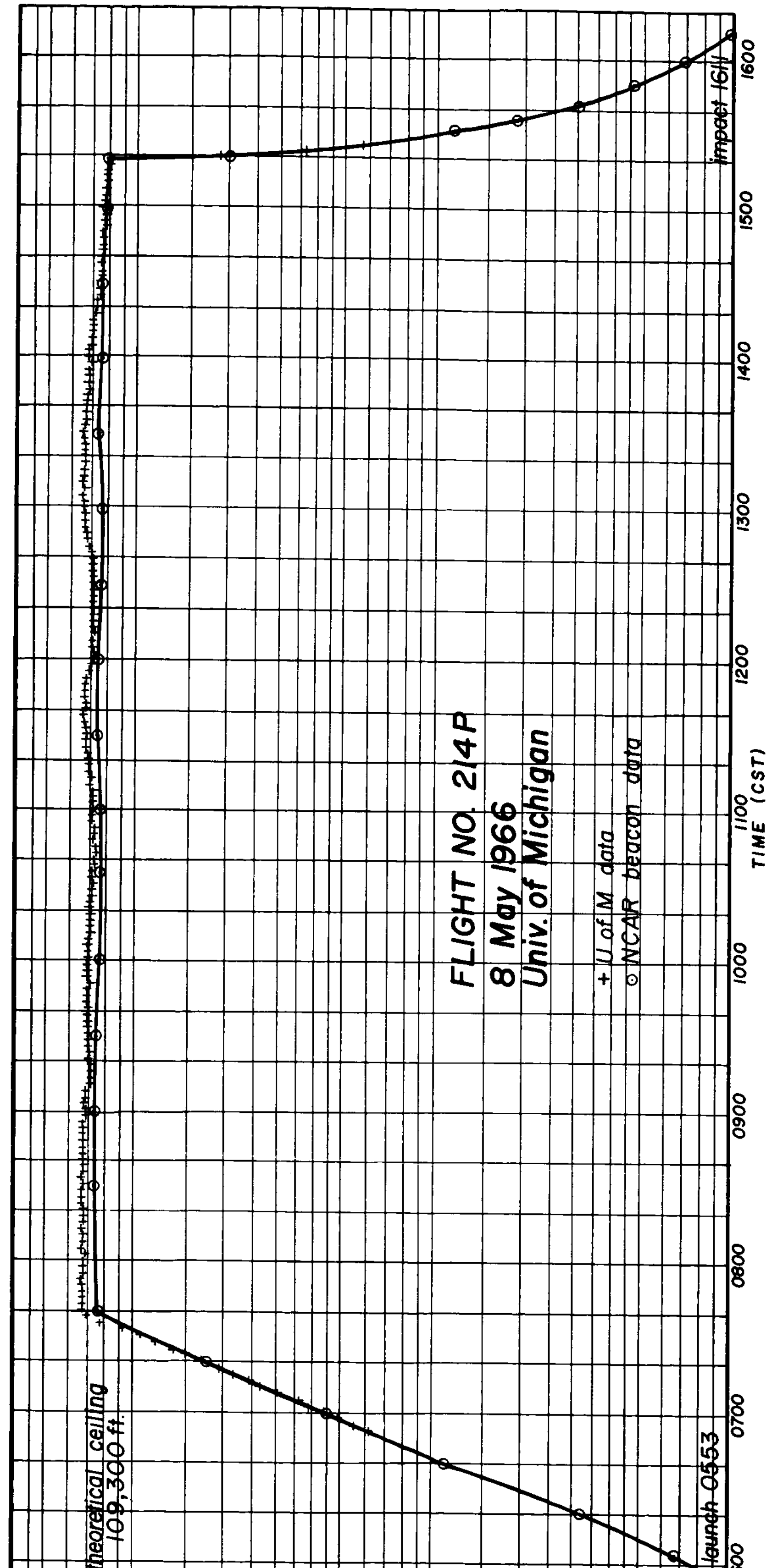
°C	S.B. 10/2/64	S.B 10/12/64	U.M. 2/65	S.B. 4/8/65	U.M. 9/65	S.B. 12/20/65	S.B. 12/29/65	U.M. 2/1/66	U.M. 7/6/66
-93°	5.00	5.00	--	4.80	4.75	4.75	4.75	4.94	--
-83°	4.70	4.70	--	4.40	4.55	4.40	4.40	4.63	4.51
-73°	4.35	4.35	--	4.10	4.15	4.00	4.10	4.25	4.16
-63°	3.85	3.90	3.45	3.75	3.70	3.50	3.60	3.77	3.70
-53°	3.40	3.35	3.05	3.25	3.20	3.05	3.10	3.30	3.19
-43°	2.75	2.75	2.55	2.60	2.65	2.50	2.55	2.75	2.61
-33°	2.30	2.15	1.95	2.00	2.00	1.85	1.90	--	1.95
-23°	1.55	1.50	1.25	1.35	1.35	1.20	1.25	--	1.25
-13°	0.80	0.75	0.45	0.60	0.55	0.50	0.50	--	0.50
-5.5°	-0.20	-0.15	--	0.00	+0.05	+0.05	+0.05	--	--

TABLE 9 F-4 MRIR CALIBRATION DATA

5-30 Micron Channel

Scanner 25°/Electronics 25°

	S. B.	S. B.	U. M.	S. B.	U. M.	S. B.	S. B.	U. M.	U. M.
°C	10/2/64	10/12/64	2/65	4/8/65	9/65	12/20/65	12/29/65	2/1/66	7/6/66
-93	5.80	5.80	--	5.70	5.80	5.65	5.70	5.98	--
-83	5.60	5.65	--	5.50	5.70	5.50	5.50	5.80	5.70
-73	5.40	5.50	--	5.35	5.55	5.35	5.35	5.60	5.50
-63	5.25	5.25	5.30	5.10	5.30	5.15	5.10	5.35	5.26
-53	5.00	5.00	5.10	4.85	5.00	4.85	4.85	5.05	5.00
-43	4.65	4.70	4.80	4.60	4.70	4.55	4.55	4.75	4.70
-33	4.30	4.35	4.40	4.25	4.30	4.20	4.25	4.40	4.33
-23	3.95	3.90	3.95	3.90	3.90	3.80	3.80	4.00	3.90
-13	3.50	3.50	3.50	3.40	3.45	3.40	3.40	3.50	3.46
-3	3.00	3.00	2.95	2.95	3.00	2.90	2.90	3.00	2.96
7	2.40	2.40	2.40	2.40	2.45	2.40	2.35	2.45	2.43
17	1.80	1.80	1.80	1.85	1.80	1.75	1.75	1.82	1.81
27	1.15	1.10	1.15	1.15	1.15	1.15	1.15	1.10	1.15
37	0.40	0.50	0.35	0.40	0.35	0.35	0.35	0.35	0.41
47	--	--	--	--	--	--	--	--	--



FLIGHT NO. 214P
8 May 1966
Univ. of Michigan
+ U of M data
⊙ NCAR beacon data
theoretical ceiling
109,300 ft.
launch 0553
impact 1611
TIME (CST)
ALTITUDE IN THOUSANDS OF FEET (ARDC ATMOS.)
PRESSURE IN MILLIBARS

Figure 1

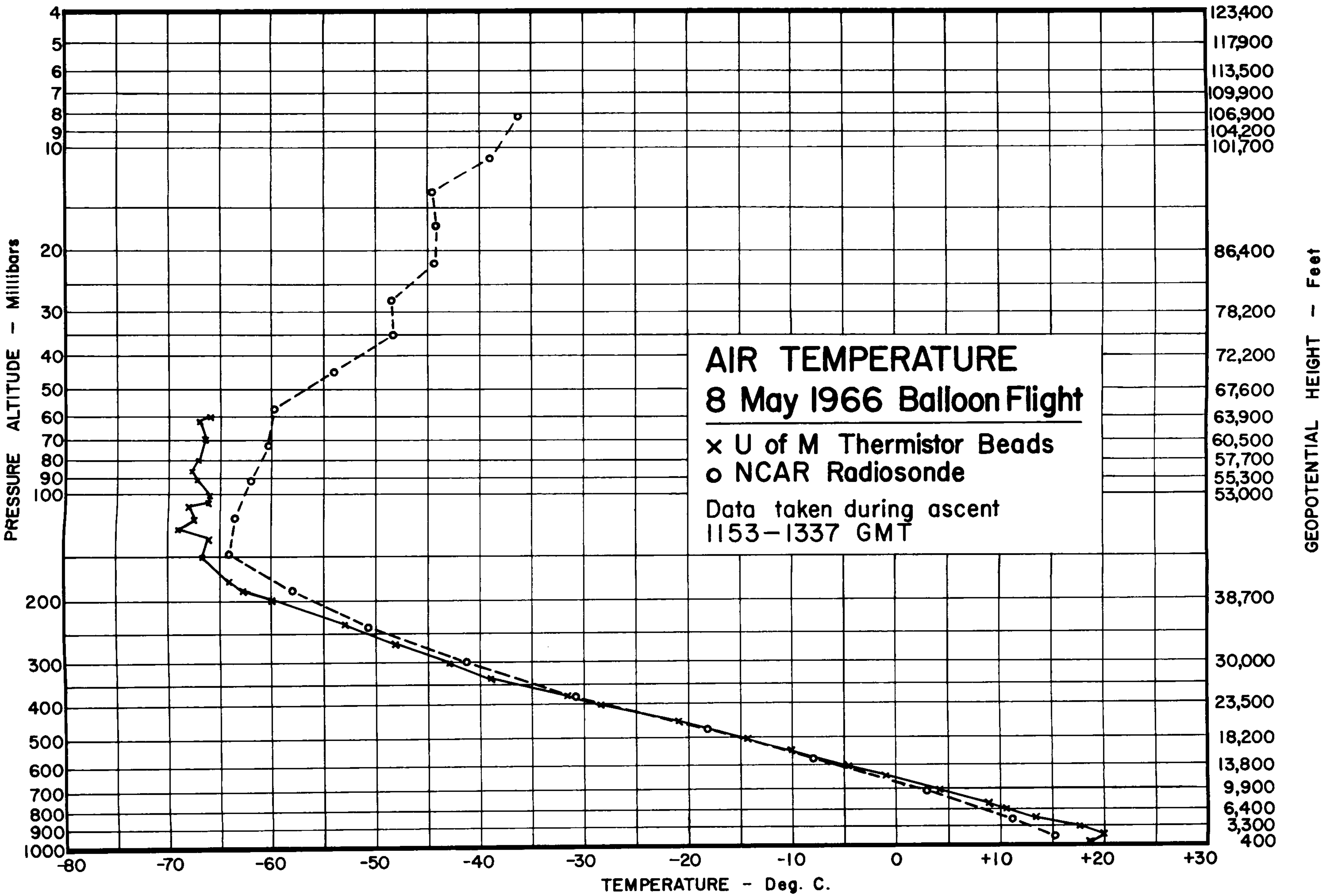

AIR TEMPERATURE
8 May 1966 Balloon Flight
× U of M Thermistor Beads
o NCAR Radiosonde
Data taken during ascent
1153–1337 GMT
PRESSURE ALTITUDE – Millibars
4
5
6
7
8
9
10
20
30
40
50
60
70
80
90
100
200
300
400
500
600
700
800
900
1000
GEOPOTENTIAL HEIGHT – Feet
123,400
117,900
113,500
109,900
106,900
104,200
101,700
86,400
78,200
72,200
67,600
63,900
60,500
57,700
55,300
53,000
38,700
30,000
23,500
18,200
13,800
9,900
6,400
3,300
400
TEMPERATURE – Deg. C.
-80
-70
-60
-50
-40
-30
-20
-10
0
+10
+20
+30

Figure 2

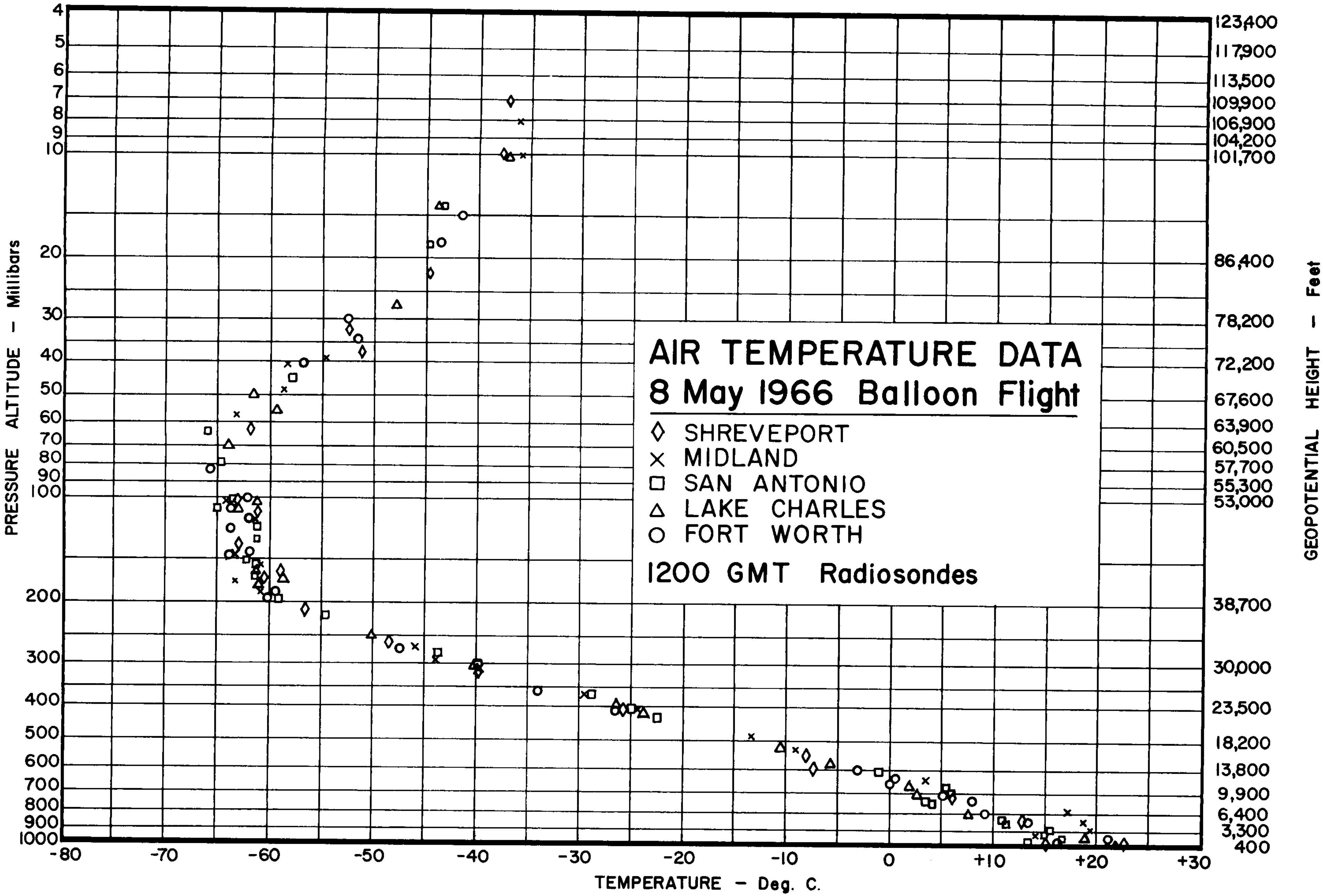

AIR TEMPERATURE DATA
8 May 1966 Balloon Flight
◇ SHREVEPORT
× MIDLAND
□ SAN ANTONIO
△ LAKE CHARLES
○ FORT WORTH
1200 GMT Radiosondes
PRESSURE ALTITUDE - Millibars
4
5
6
7
8
9
10
20
30
40
50
60
70
80
90
100
200
300
400
500
600
700
800
900
1000
GEOPOTENTIAL HEIGHT - Feet
123,400
117,900
113,500
109,900
106,900
104,200
101,700
86,400
78,200
72,200
67,600
63,900
60,500
57,700
55,300
53,000
38,700
30,000
23,500
18,200
13,800
9,900
6,400
3,300
400
TEMPERATURE - Deg. C.
-80
-70
-60
-50
-40
-30
-20
-10
0
+10
+20
+30

Figure 3

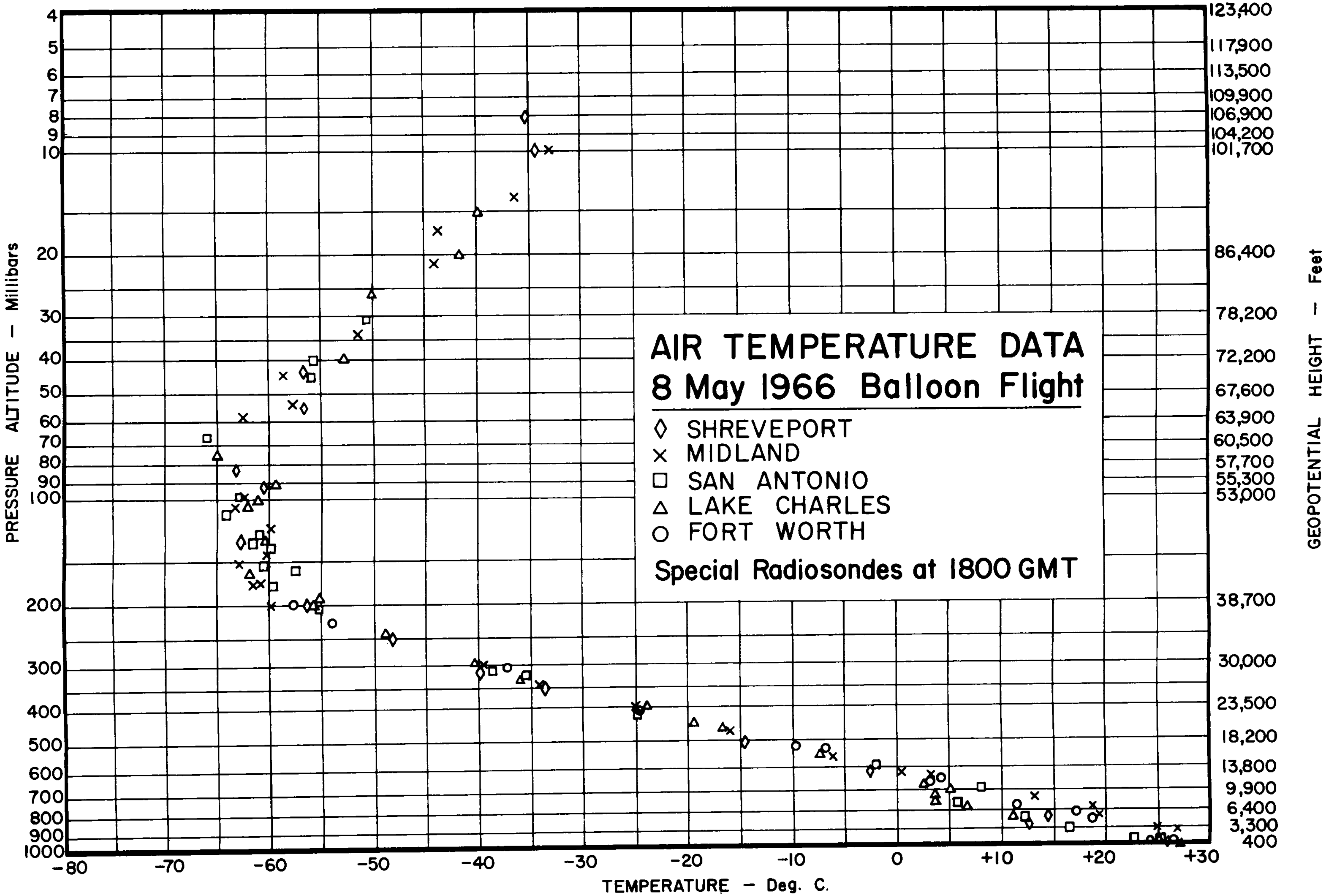

AIR TEMPERATURE DATA
8 May 1966 Balloon Flight
◊ SHREVEPORT
× MIDLAND
□ SAN ANTONIO
△ LAKE CHARLES
○ FORT WORTH
Special Radiosondes at 1800 GMT
PRESSURE ALTITUDE — Millibars
4
5
6
7
8
9
10
20
30
40
50
60
70
80
90
100
200
300
400
500
600
700
800
900
1000
GEOPOTENTIAL HEIGHT — Feet
123,400
117,900
113,500
109,900
106,900
104,200
101,700
86,400
78,200
72,200
67,600
63,900
60,500
57,700
55,300
53,000
38,700
30,000
23,500
18,200
13,800
9,900
6,400
3,300
400
TEMPERATURE — Deg. C.
−80
−70
−60
−50
−40
−30
−20
−10
0
+10
+20
+30

Figure 4

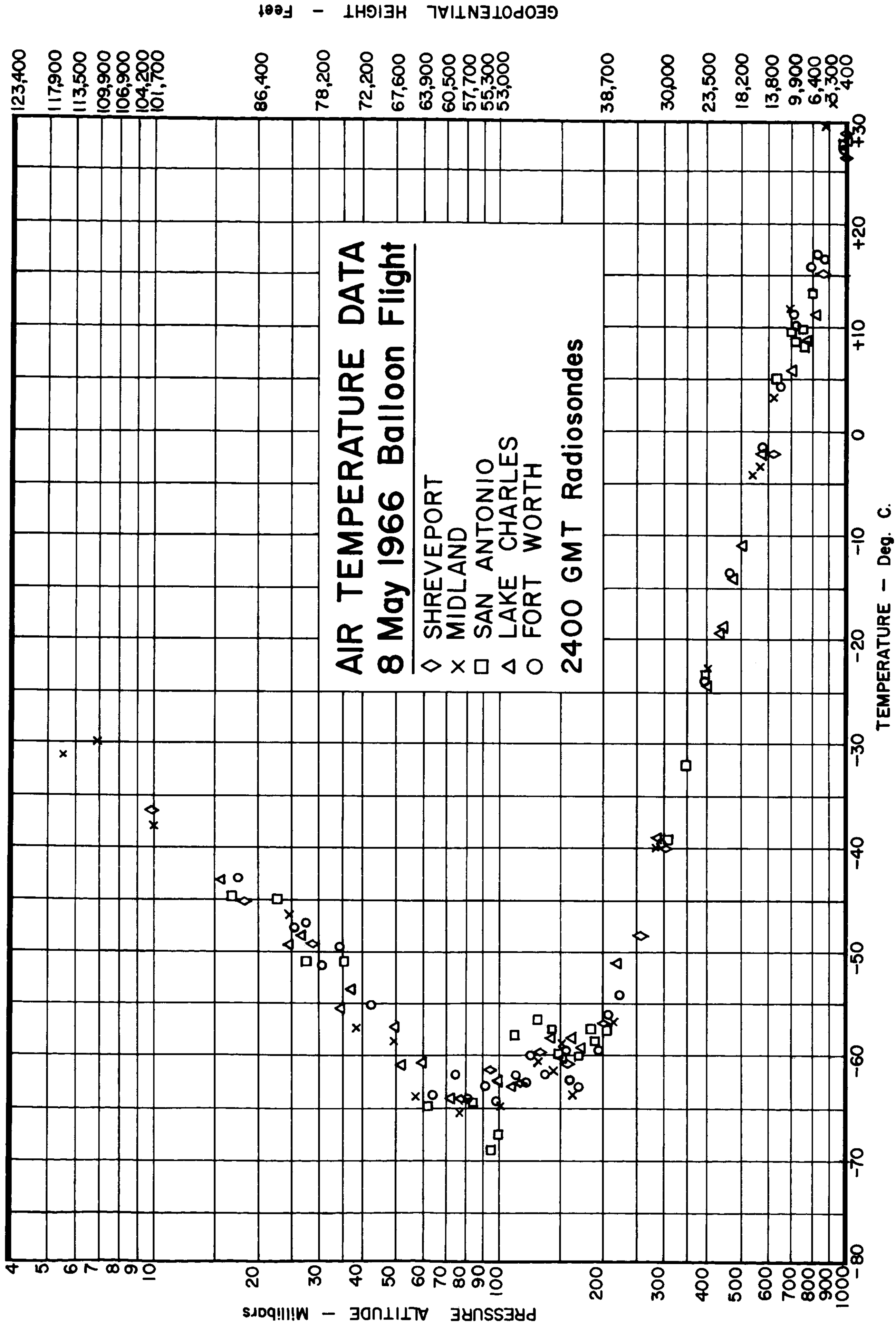

AIR TEMPERATURE DATA
8 May 1966 Balloon Flight
◇ SHREVEPORT
× MIDLAND
□ SAN ANTONIO
△ LAKE CHARLES
○ FORT WORTH
2400 GMT Radiosondes
GEOPOTENTIAL HEIGHT - Feet
123,400
117,900
113,500
109,900
106,900
104,200
101,700
86,400
78,200
72,200
67,600
63,900
60,500
57,700
55,300
53,000
38,700
30,000
23,500
18,200
13,800
9,900
6,400
3,300
400
PRESSURE ALTITUDE - Millibars
4
5
6
7
8
9
10
20
30
40
50
60
70
80
90
100
200
300
400
500
600
700
800
900
1000
TEMPERATURE - Deg. C.
-80
-70
-60
-50
-40
-30
-20
-10
0
+10
+20
+30

Figure 5

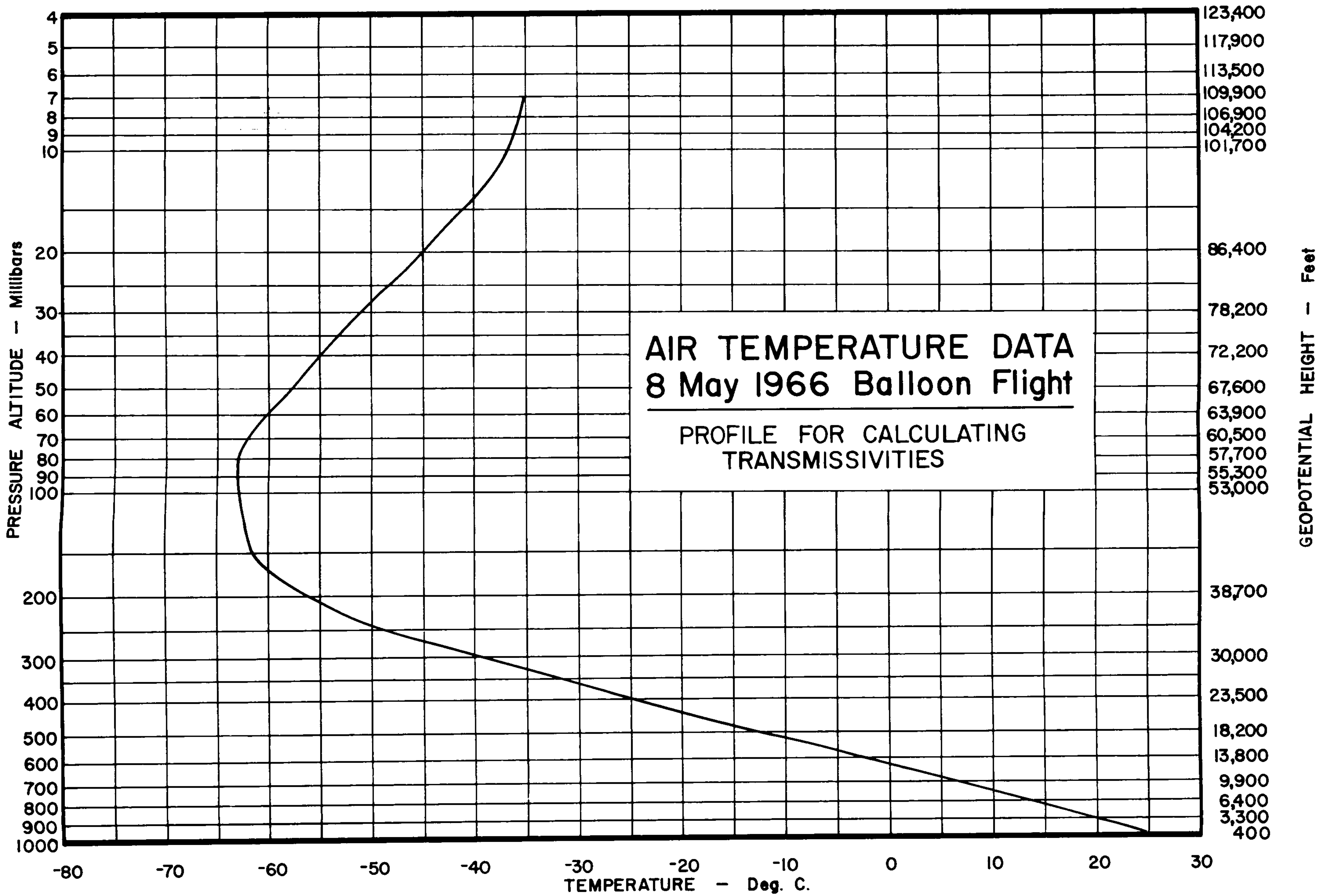

AIR TEMPERATURE DATA
8 May 1966 Balloon Flight
PROFILE FOR CALCULATING TRANSMISSIVITIES
PRESSURE ALTITUDE — Millibars
4
5
6
7
8
9
10
20
30
40
50
60
70
80
90
100
200
300
400
500
600
700
800
900
1000
GEOPOTENTIAL HEIGHT — Feet
123,400
117,900
113,500
109,900
106,900
104,200
101,700
86,400
78,200
72,200
67,600
63,900
60,500
57,700
55,300
53,000
38,700
30,000
23,500
18,200
13,800
9,900
6,400
3,300
400
TEMPERATURE — Deg. C.
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20
30

Figure 6

SUN AZIMUTH AND ELEVATION ANGLES
8 May 1966 Balloon Flight

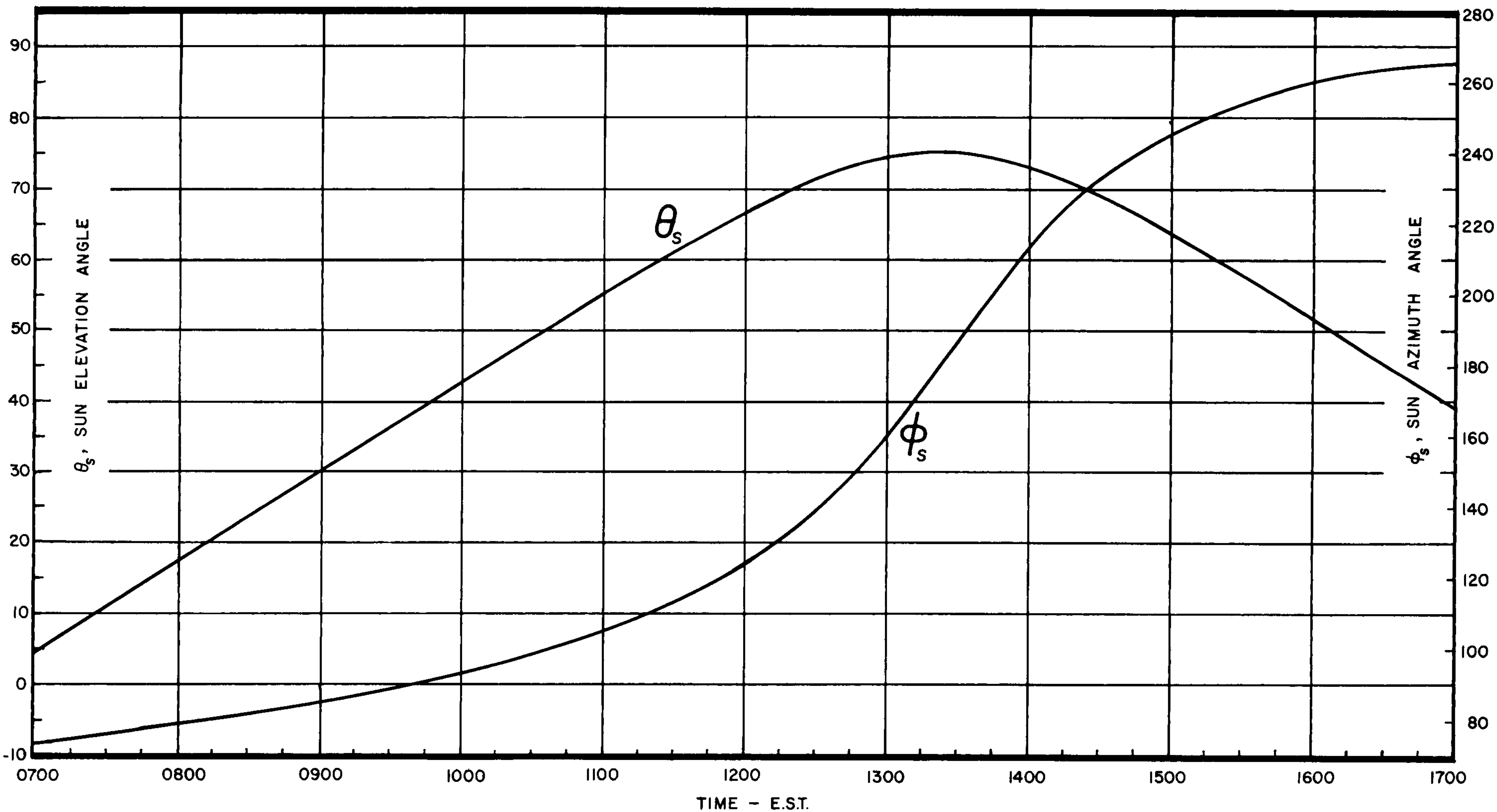


Figure 7

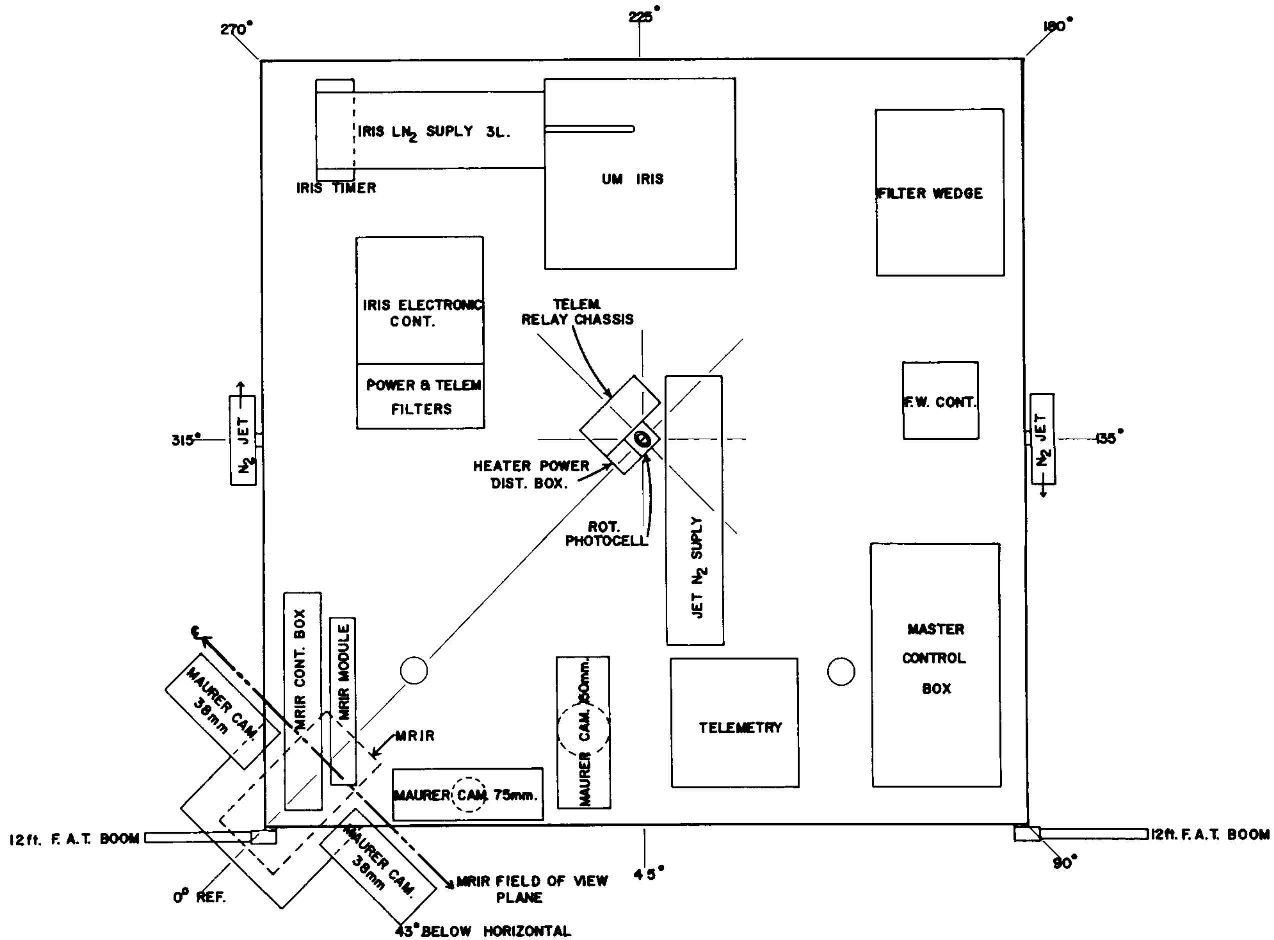
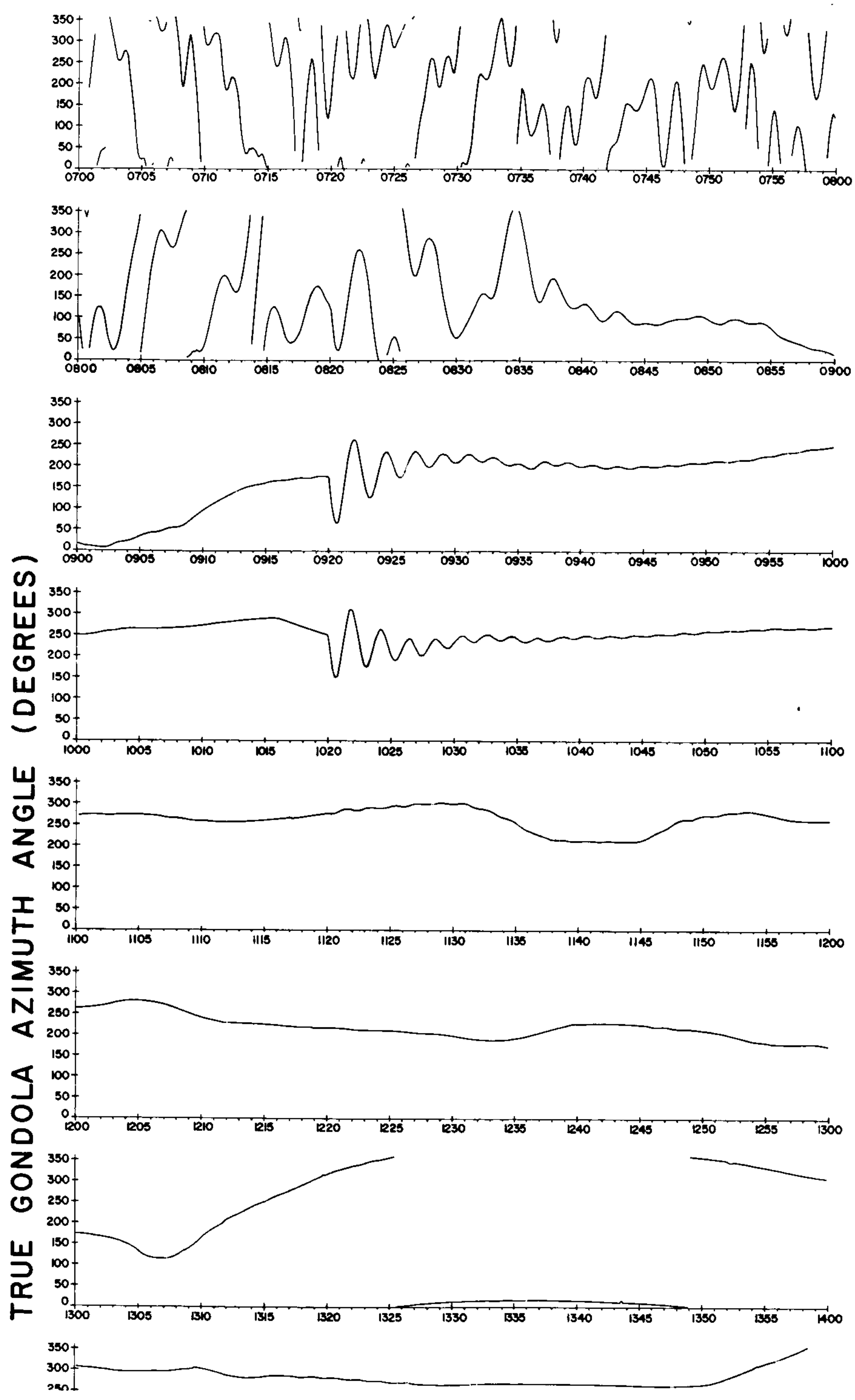

270°
225°
180°
IRIS LN2 SUPLY 3L.
IRIS TIMER
UM IRIS
FILTER WEDGE
IRIS ELECTRONIC CONT.
POWER & TELEM FILTERS
TELEM. RELAY CHASSIS
F.W. CONT.
315°
N2 JET
N2 JET
135°
HEATER POWER DIST. BOX.
ROT. PHOTOCELL
JET N2 SUPLY
MASTER CONTROL BOX
MRIR CONT. BOX
MRIR MODULE
MAURER CAM. 38mm
MRIR
MAURER CAM. 50mm.
TELEMETRY
MAURER CAM. 75mm.
12ft. F.A.T. BOOM
12ft. F.A.T. BOOM
0° REF.
MAURER CAM. 38mm
MRIR FIELD OF VIEW PLANE
43° BELOW HORIZONTAL
45°
90°

Figure 8


TRUE GONDOLA AZIMUTH ANGLE (DEGREES)
0 50 100 150 200 250 300 350
0700 0705 0710 0715 0720 0725 0730 0735 0740 0745 0750 0755 0800
0800 0805 0810 0815 0820 0825 0830 0835 0840 0845 0850 0855 0900
0900 0905 0910 0915 0920 0925 0930 0935 0940 0945 0950 0955 1000
1000 1005 1010 1015 1020 1025 1030 1035 1040 1045 1050 1055 1100
1100 1105 1110 1115 1120 1125 1130 1135 1140 1145 1150 1155 1200
1200 1205 1210 1215 1220 1225 1230 1235 1240 1245 1250 1255 1300
1300 1305 1310 1315 1320 1325 1330 1335 1340 1345 1350 1355 1400

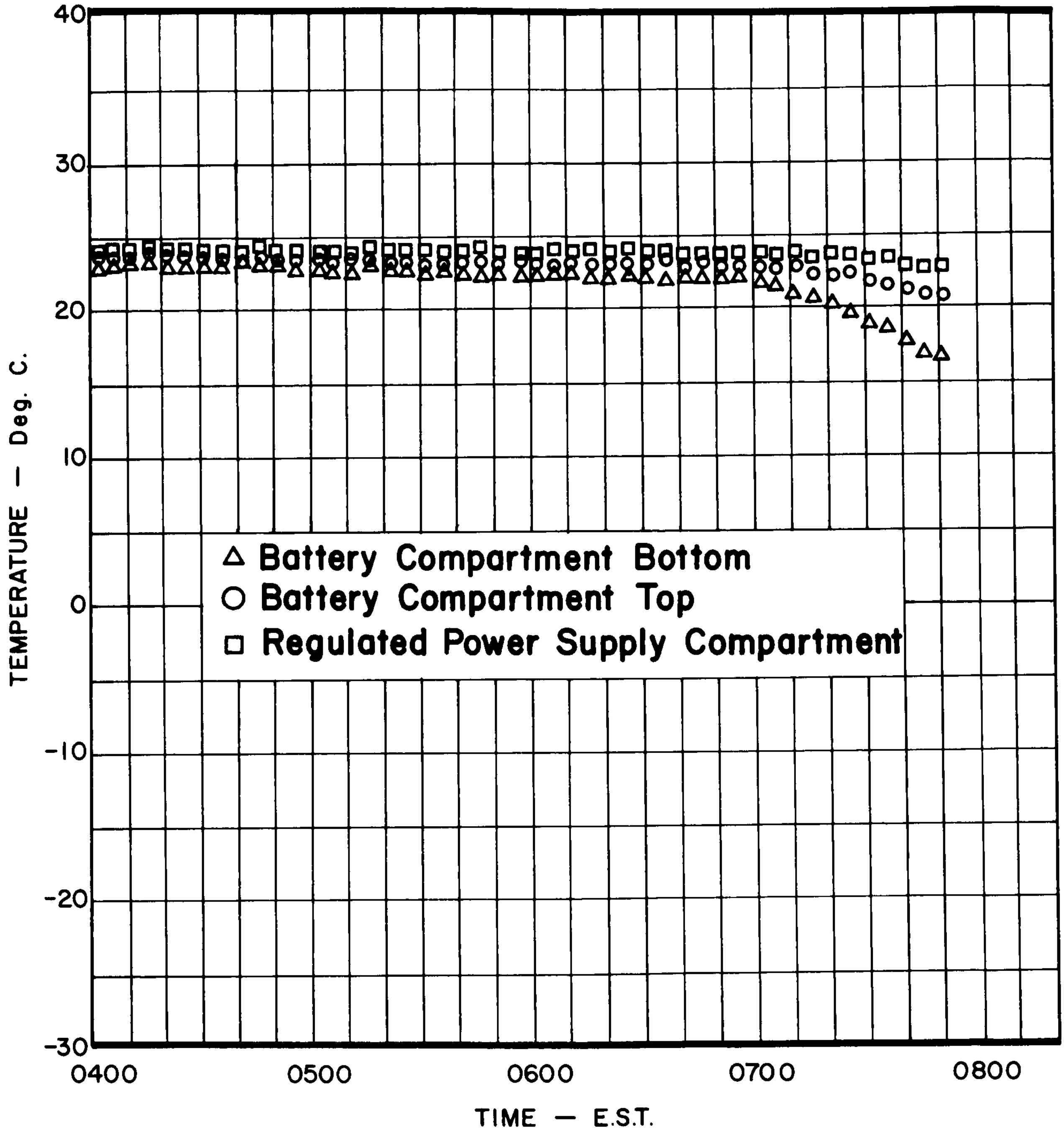
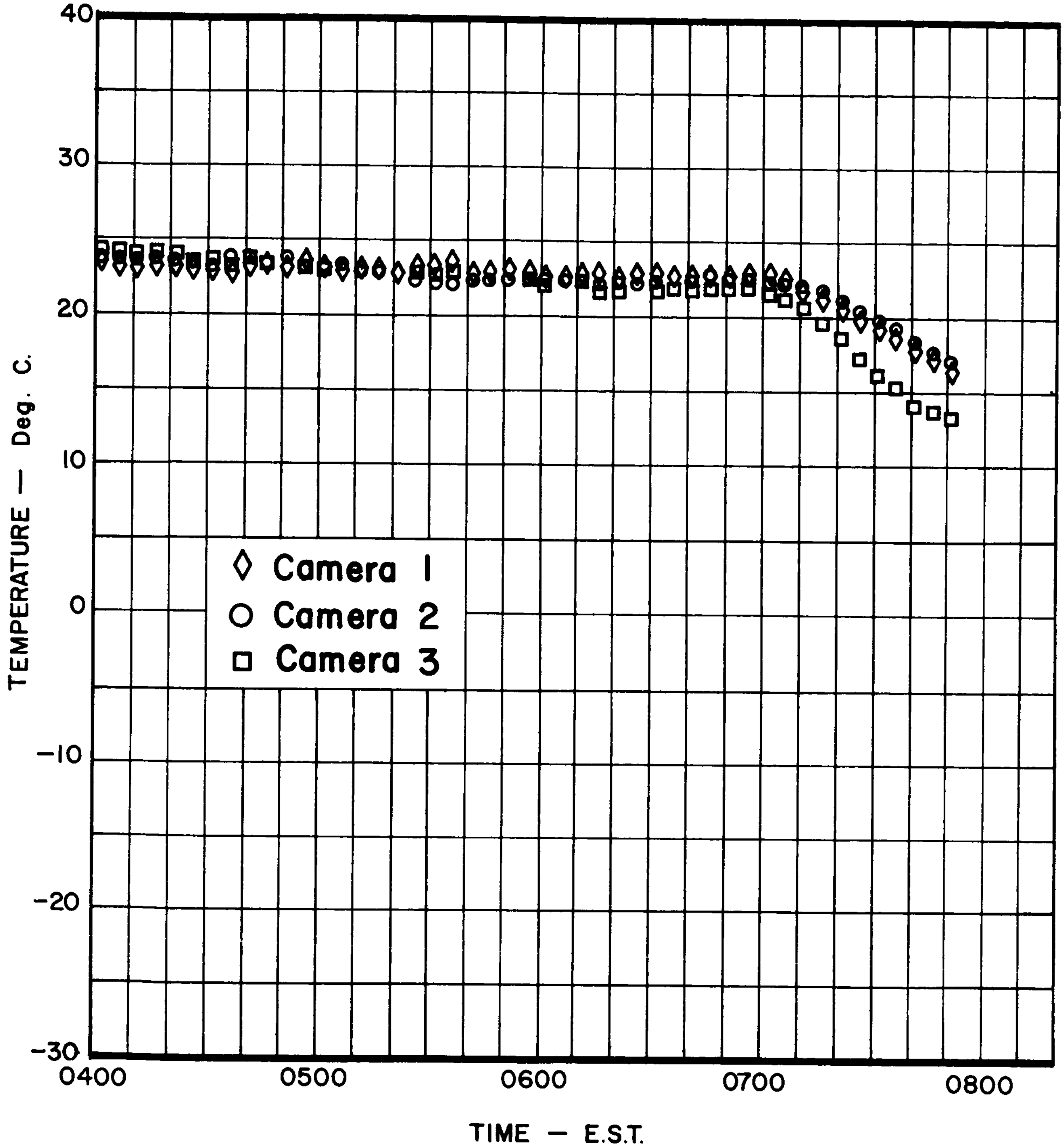

40
30
20
10
0
-10
-20
-30
TEMPERATURE — Deg. C.
0400
0500
0600
0700
0800
TIME — E.S.T.
Battery Compartment Bottom
Battery Compartment Top
Regulated Power Supply Compartment

Figure 10



40
30
20
10
0
−10
−20
−30
TEMPERATURE — Deg. C.
0400
0500
0600
0700
0800
TIME — E.S.T.
◊ Camera 1
○ Camera 2
□ Camera 3

Figure 11

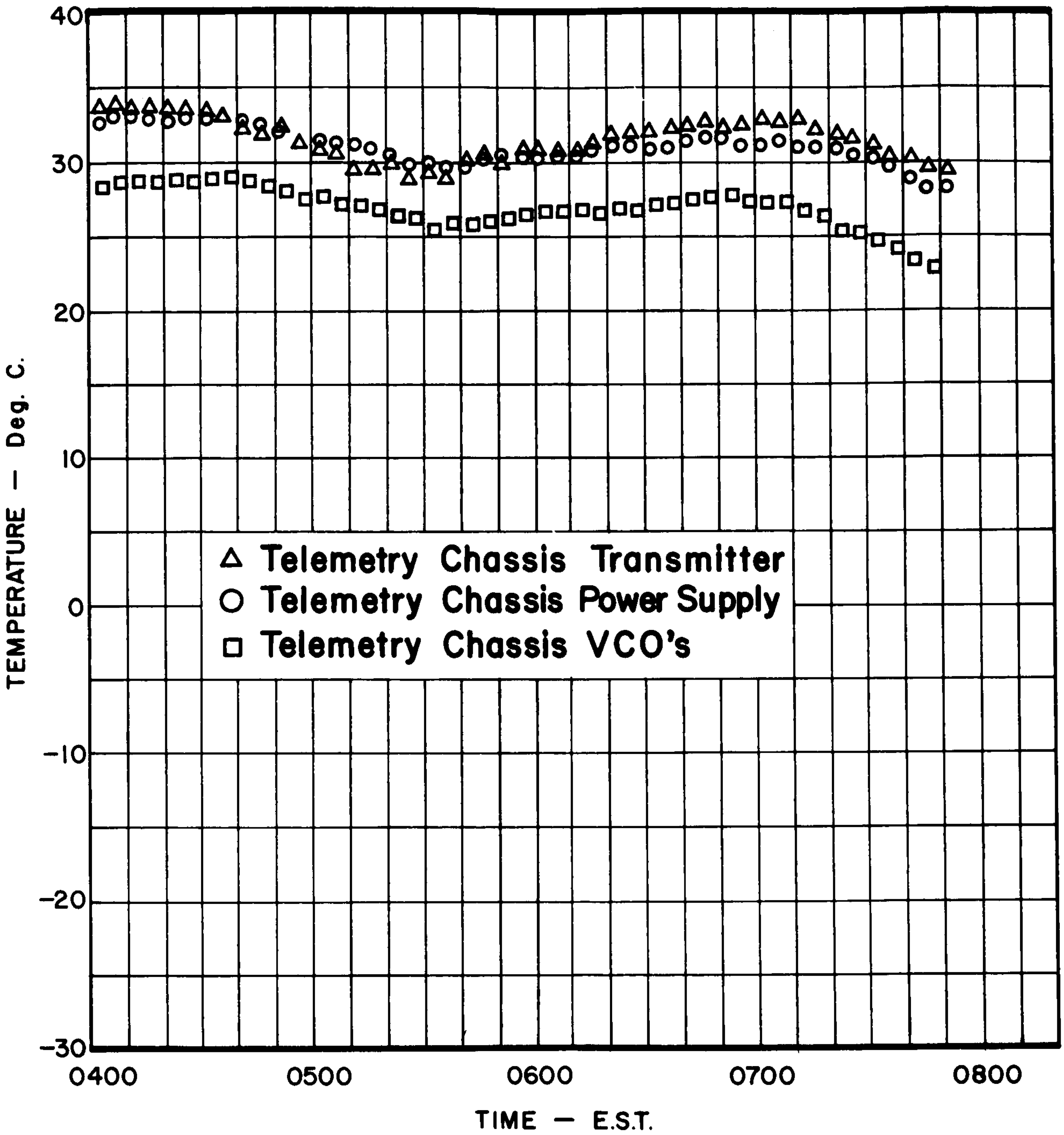

40
30
20
10
0
−10
−20
−30
0400
0500
0600
0700
0800
TEMPERATURE — Deg. C.
TIME — E.S.T.
Telemetry Chassis Transmitter
Telemetry Chassis Power Supply
Telemetry Chassis VCO's

Figure 12

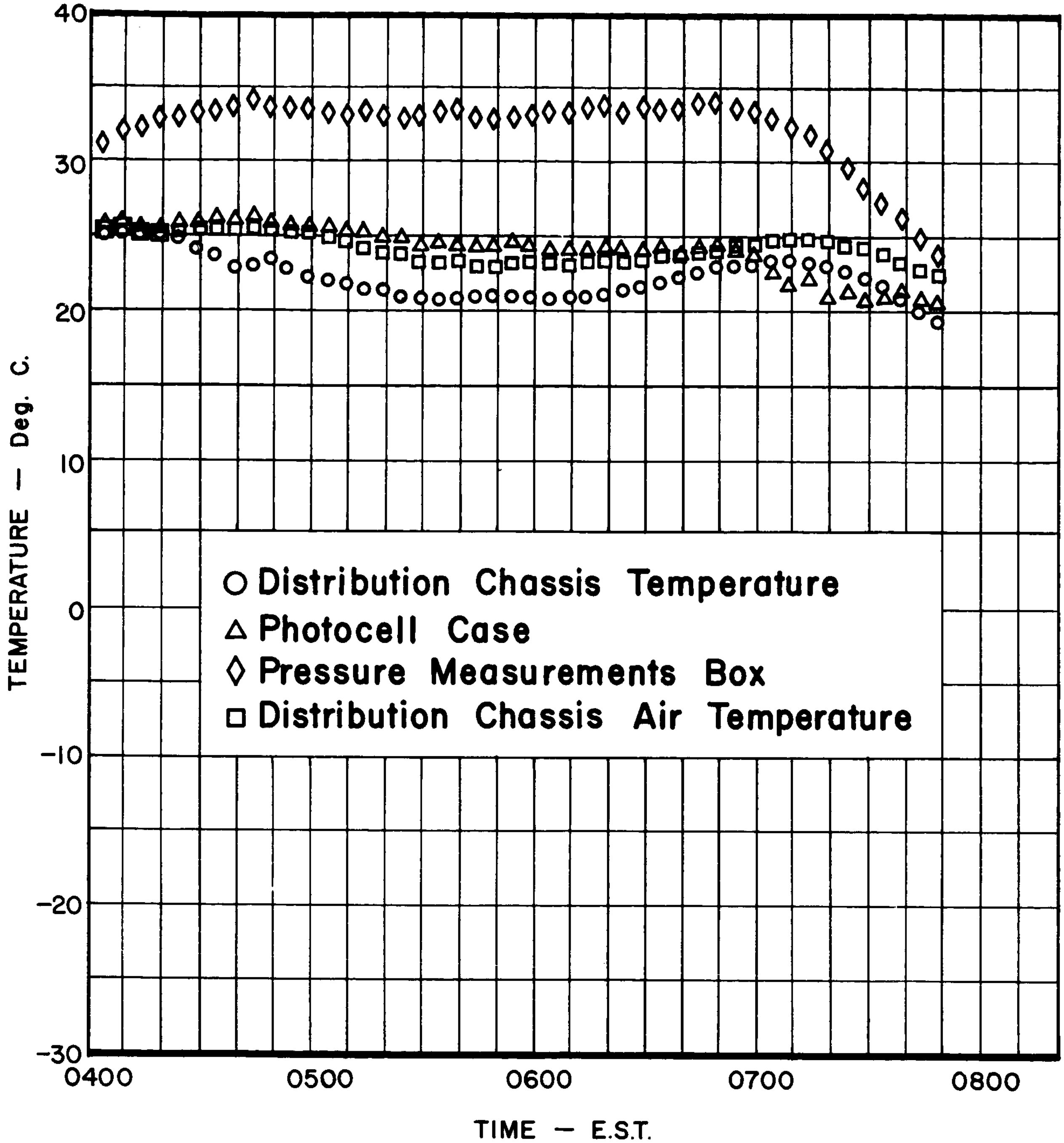
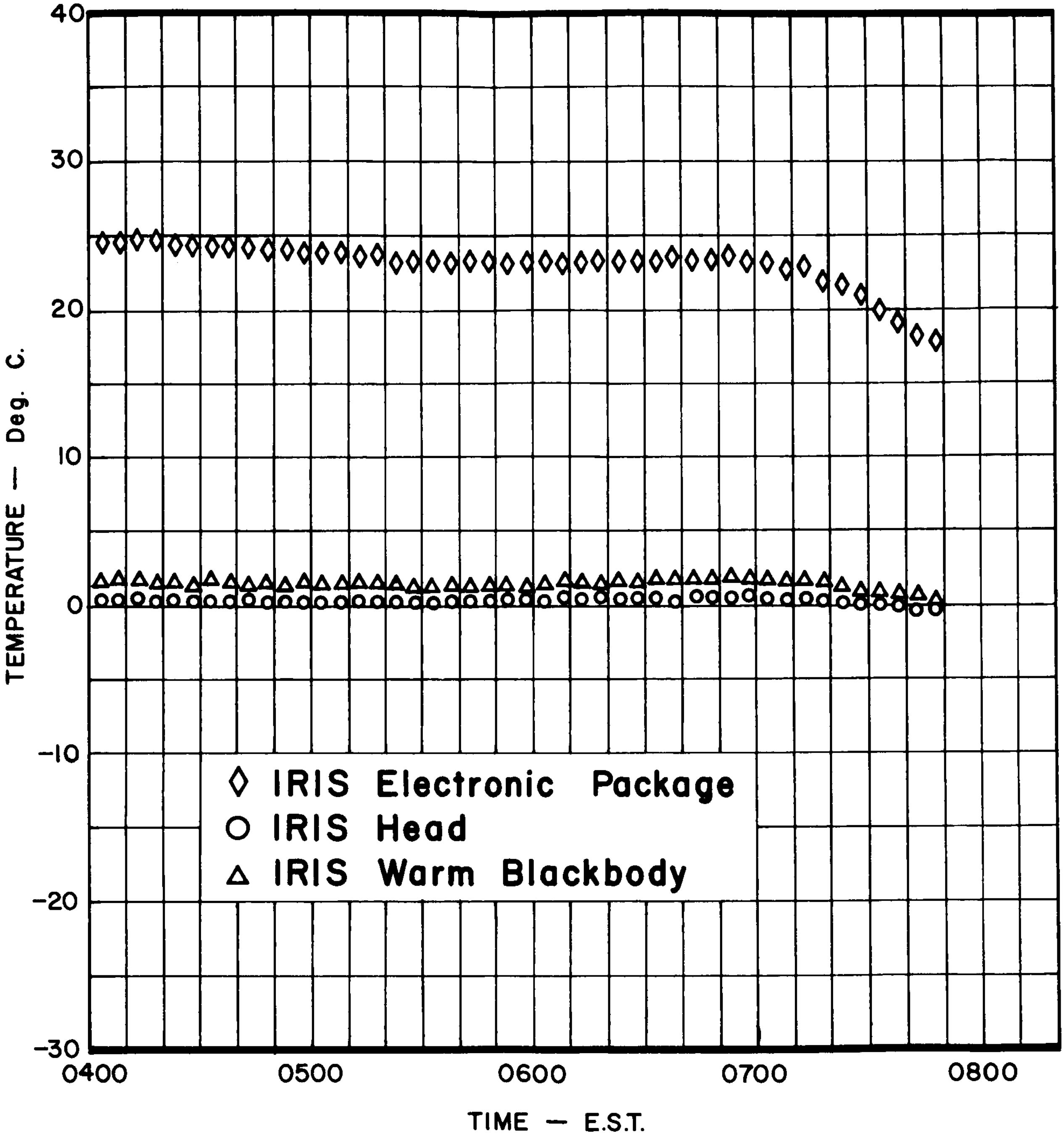

40
30
20
10
0
-10
-20
-30
TEMPERATURE — Deg. C.
0400
0500
0600
0700
0800
TIME — E.S.T.
O Distribution Chassis Temperature
△ Photocell Case
◊ Pressure Measurements Box
□ Distribution Chassis Air Temperature

Figure 13



40
30
20
10
0
-10
-20
-30
TEMPERATURE — Deg. C.
◊ IRIS Electronic Package
○ IRIS Head
△ IRIS Warm Blackbody
0400
0500
0600
0700
0800
TIME — E.S.T.

Figure 14

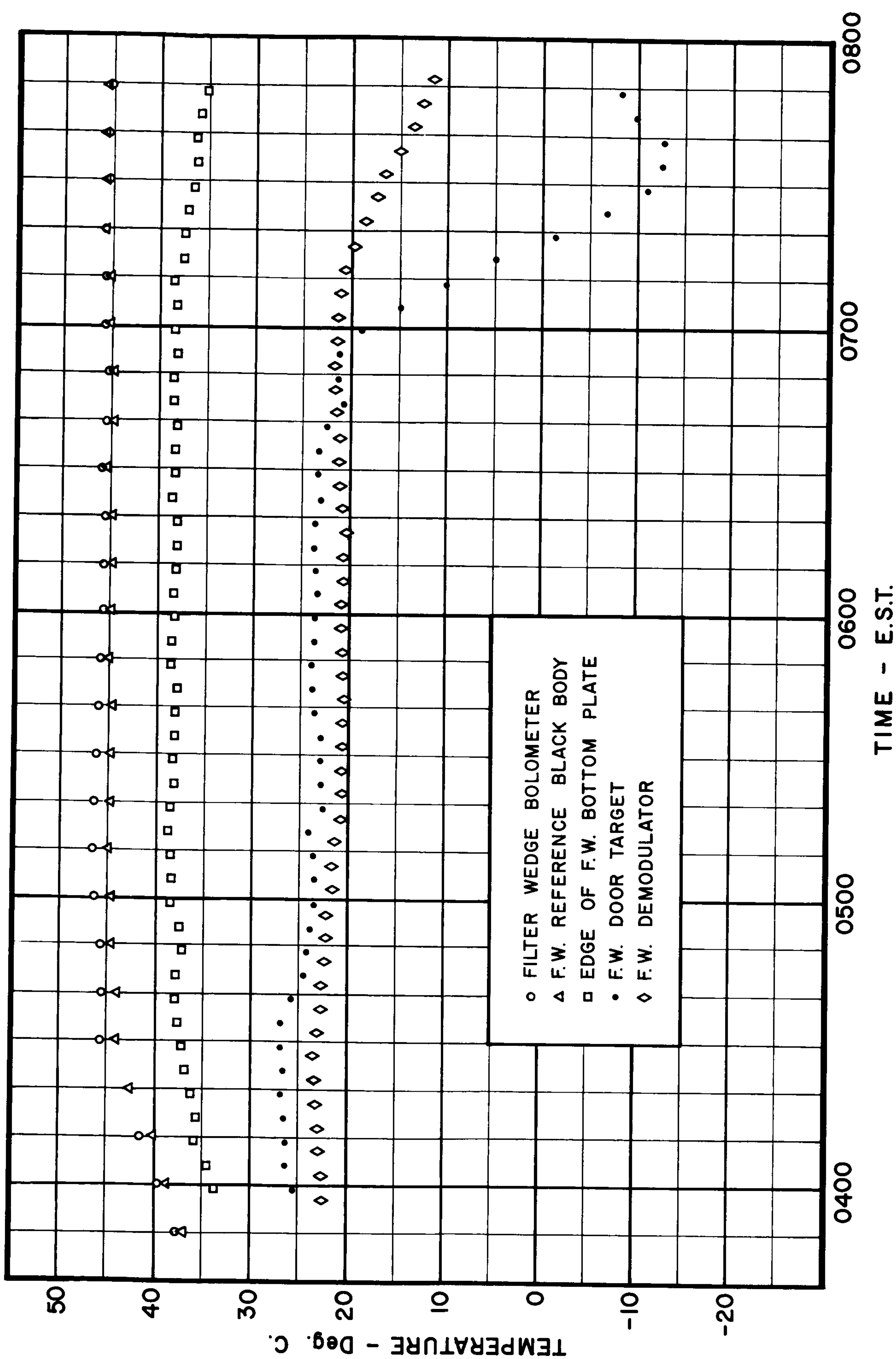

TEMPERATURE - Deg. C.
50
40
30
20
10
0
-10
-20
0400
0500
0600
0700
0800
TIME - E.S.T.
○ FILTER WEDGE BOLOMETER
◁ F.W. REFERENCE BLACK BODY
□ EDGE OF F.W. BOTTOM PLATE
• F.W. DOOR TARGET
◇ F.W. DEMODULATOR

Figure 15

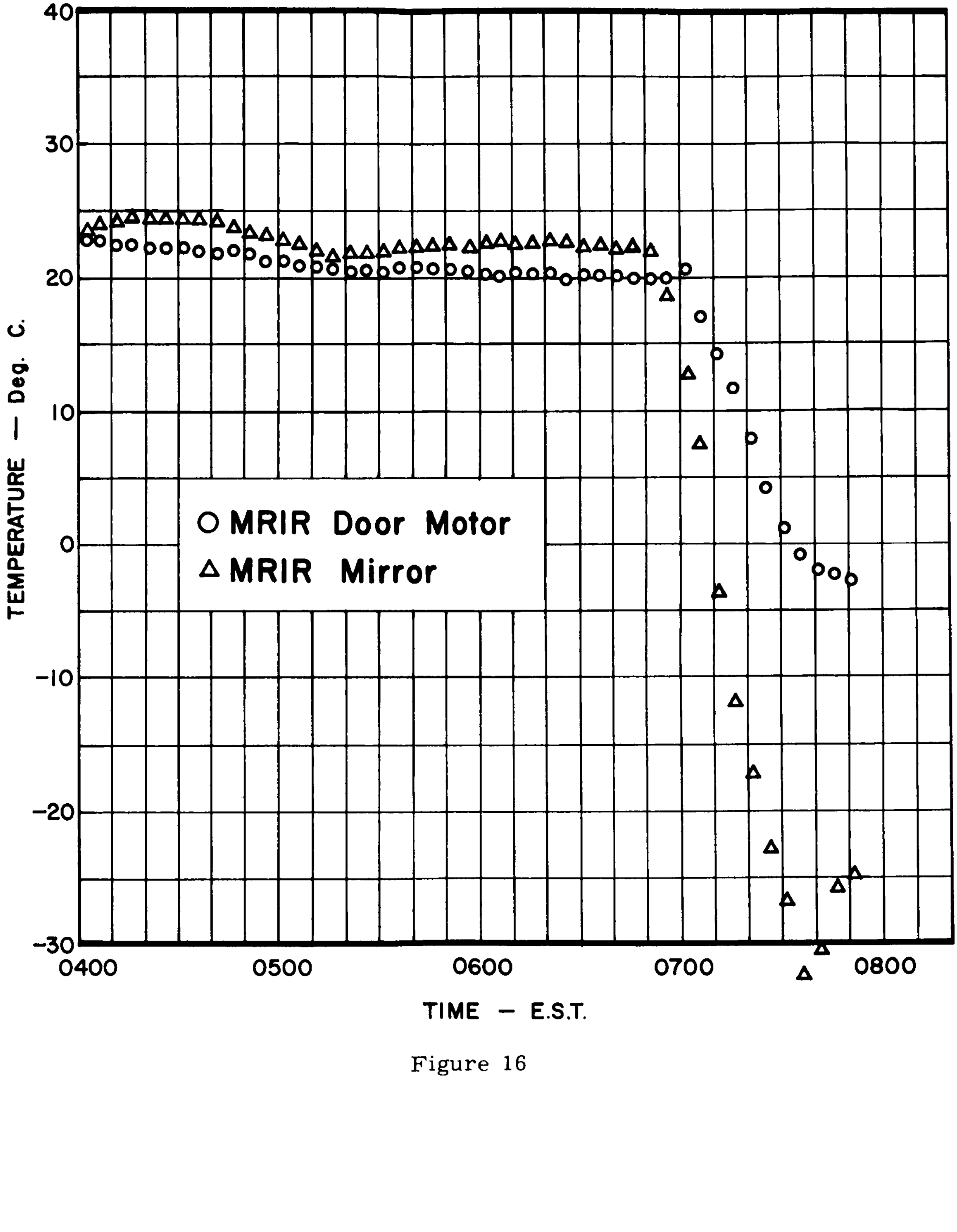
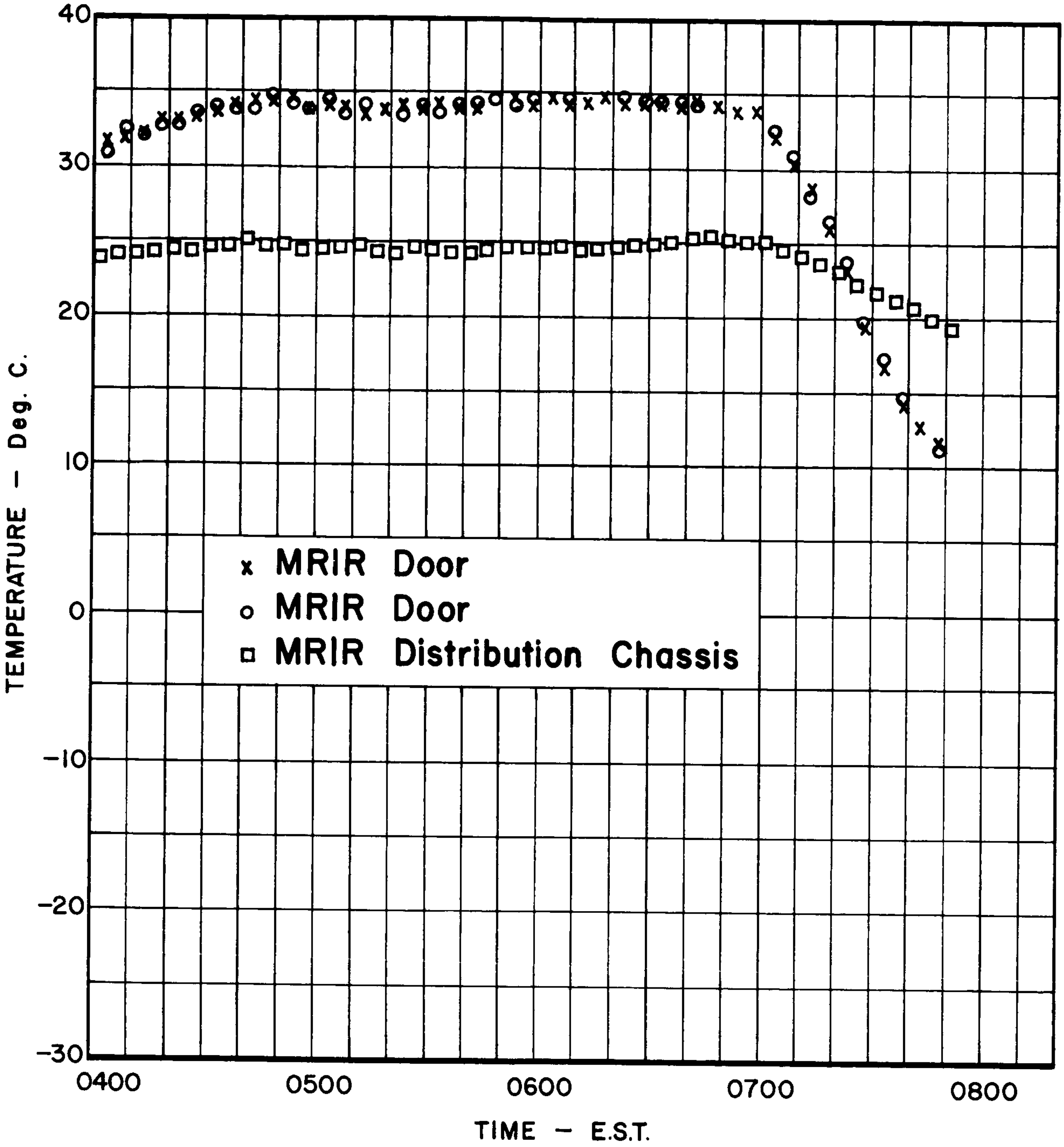
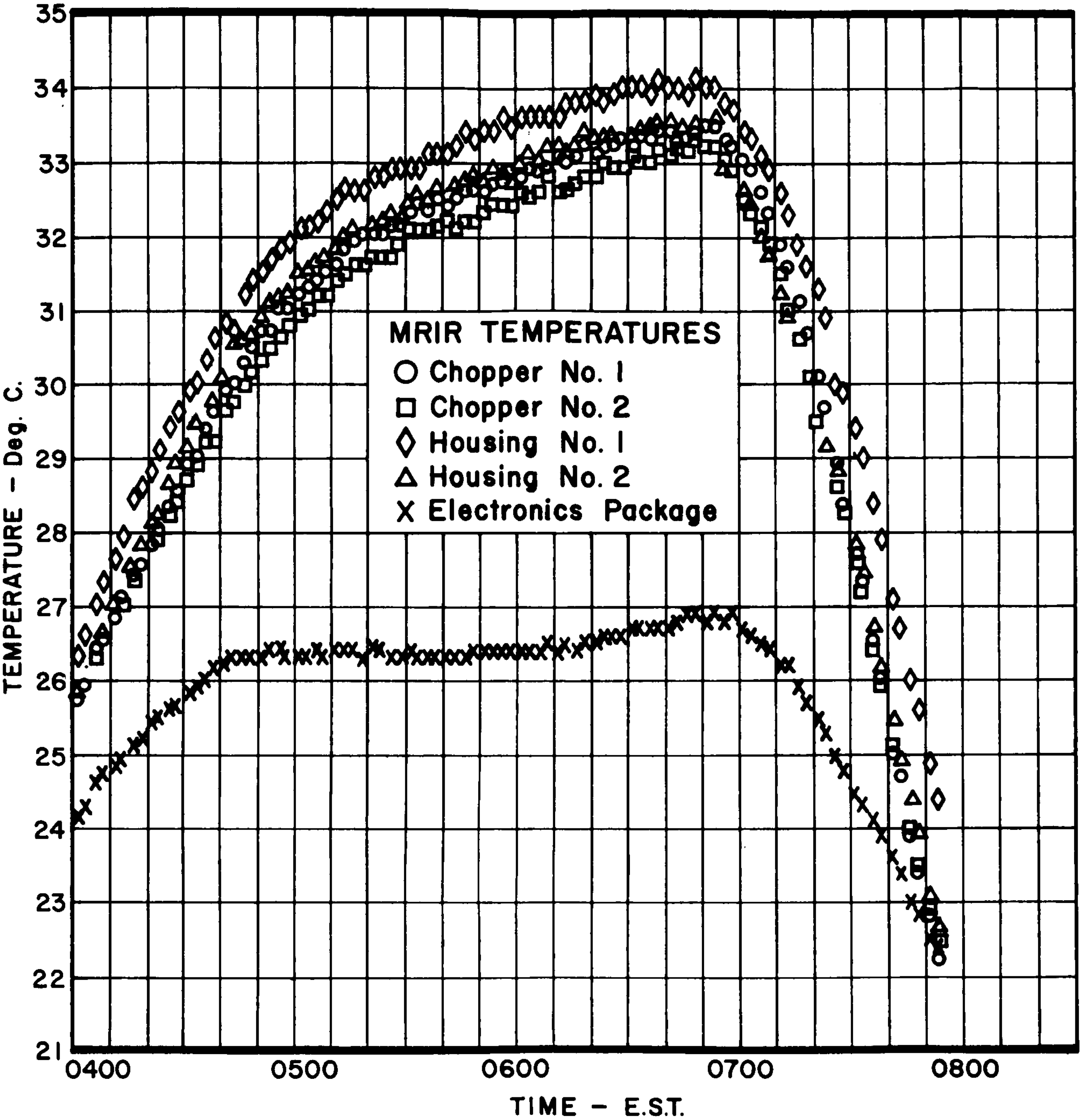

40
30
20
10
0
-10
-20
-30
TEMPERATURE — Deg. C.
0400
0500
0600
0700
0800
TIME — E.S.T.
○ MRIR Door Motor
△ MRIR Mirror

Figure 16



40
30
20
10
0
−10
−20
−30
TEMPERATURE – Deg. C.
x MRIR Door
o MRIR Door
□ MRIR Distribution Chassis
0400
0500
0600
0700
0800
TIME – E.S.T.

Figure 17



MRIR TEMPERATURES
O Chopper No. 1
□ Chopper No. 2
◇ Housing No. 1
△ Housing No. 2
X Electronics Package
TEMPERATURE - Deg. C.
TIME - E.S.T.
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
0400
0500
0600
0700
0800

Figure 18

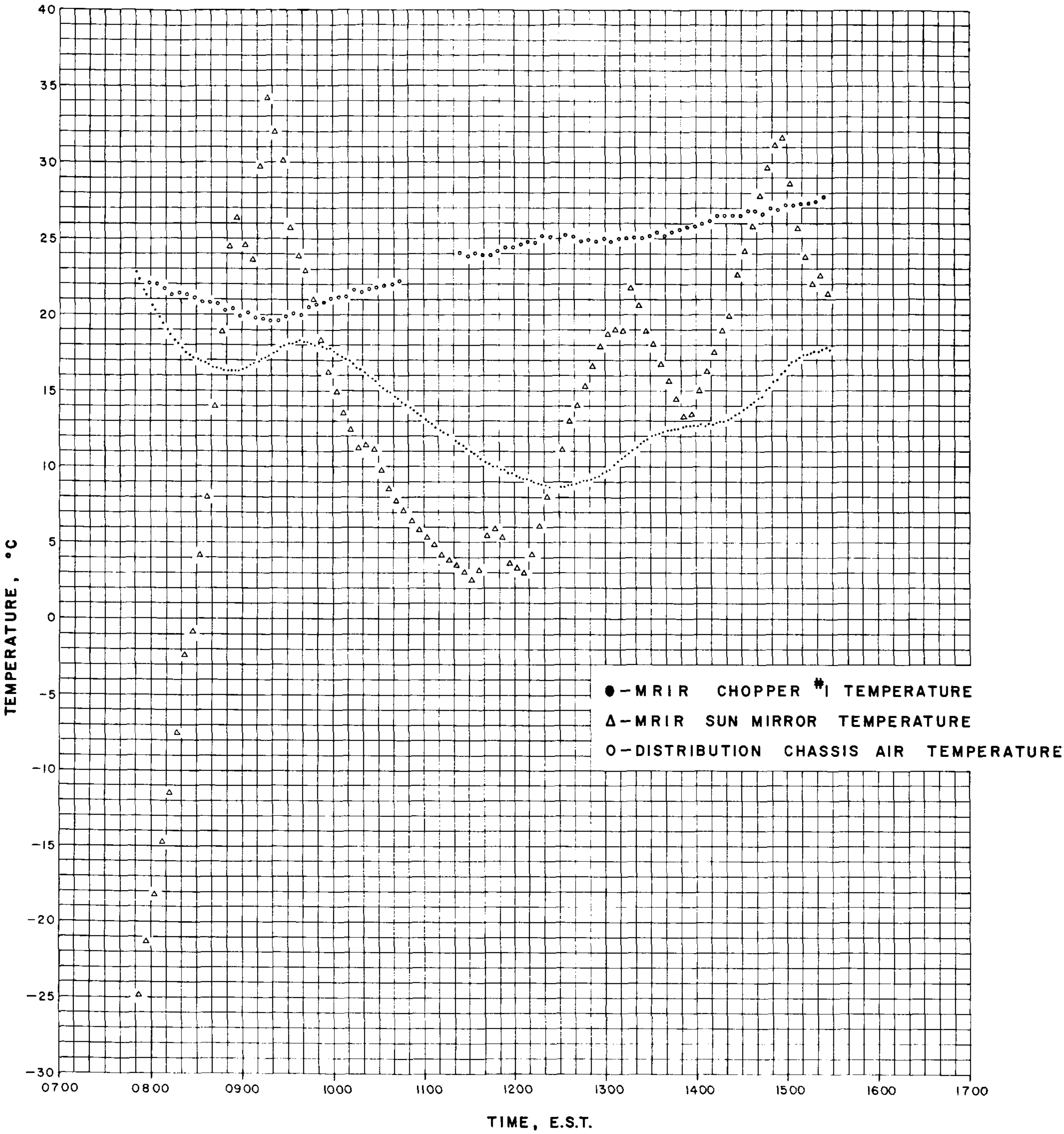
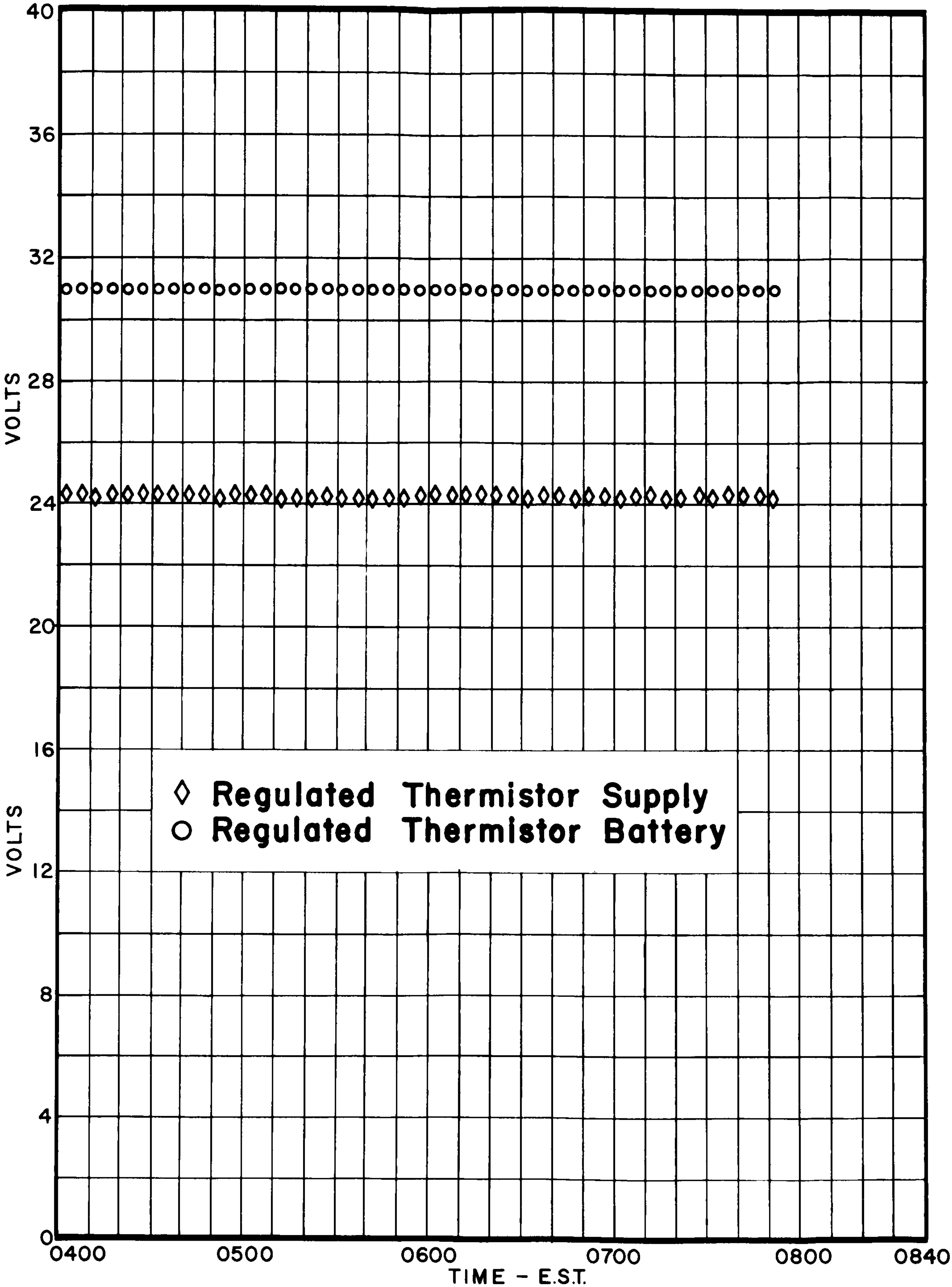

40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
0700
0800
0900
1000
1100
1200
1300
1400
1500
1600
1700
TEMPERATURE, °C
TIME, E.S.T.
●-MRIR CHOPPER #1 TEMPERATURE
Δ-MRIR SUN MIRROR TEMPERATURE
O-DISTRIBUTION CHASSIS AIR TEMPERATURE

Figure 19



40
36
32
28
24
20
16
12
8
4
0
VOLTS
VOLTS
◊ Regulated Thermistor Supply
○ Regulated Thermistor Battery
0400
0500
0600
0700
0800
0840
TIME - E.S.T.

Figure 20